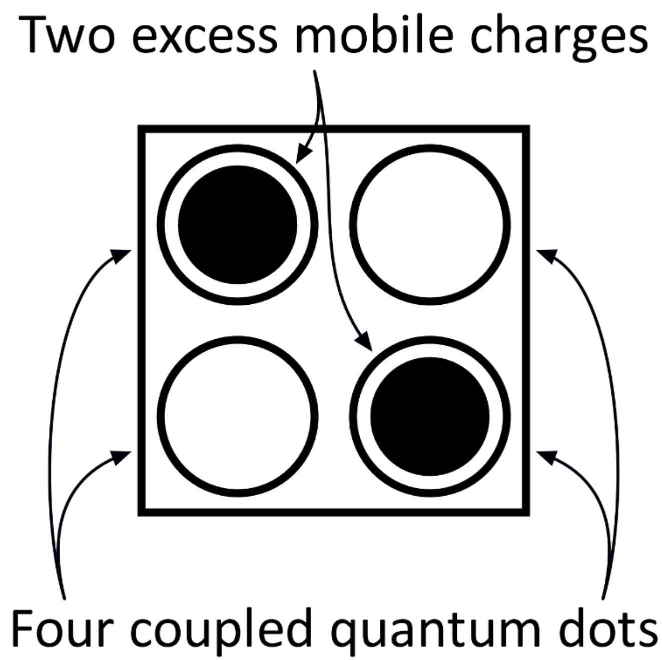
Single Electron Transistors for Molecular Computer Readout

Matthew Filmer

Quantum Dot Cellular Automata (QCA)



[1] Snider, 1999

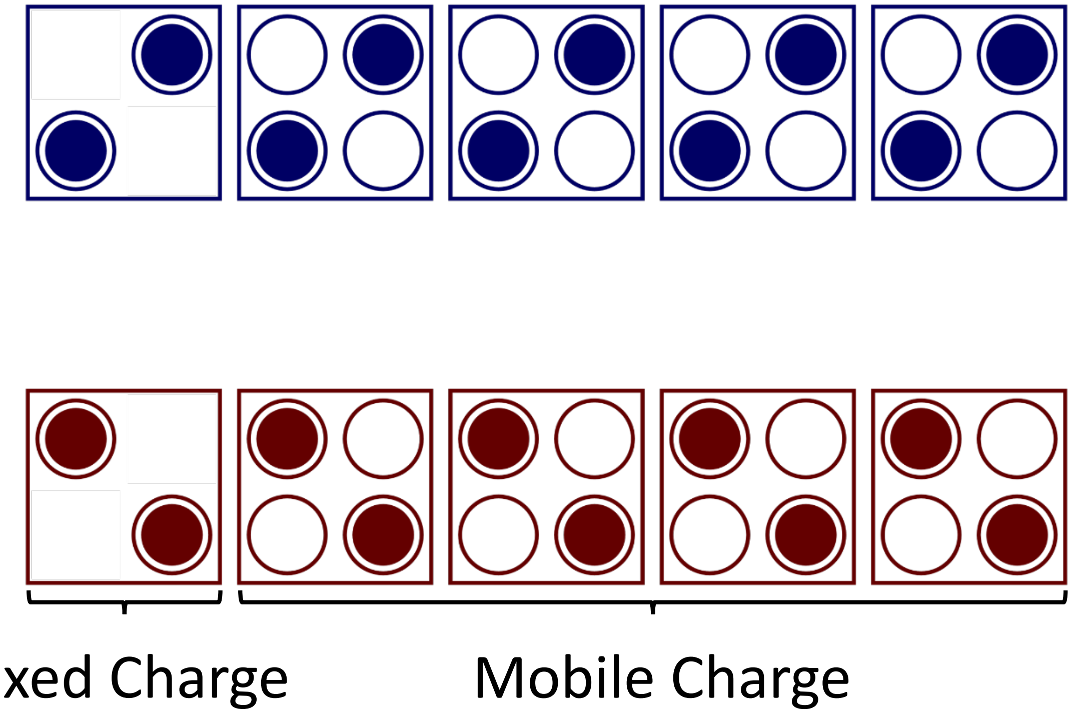
QCA States

0 State

1 State

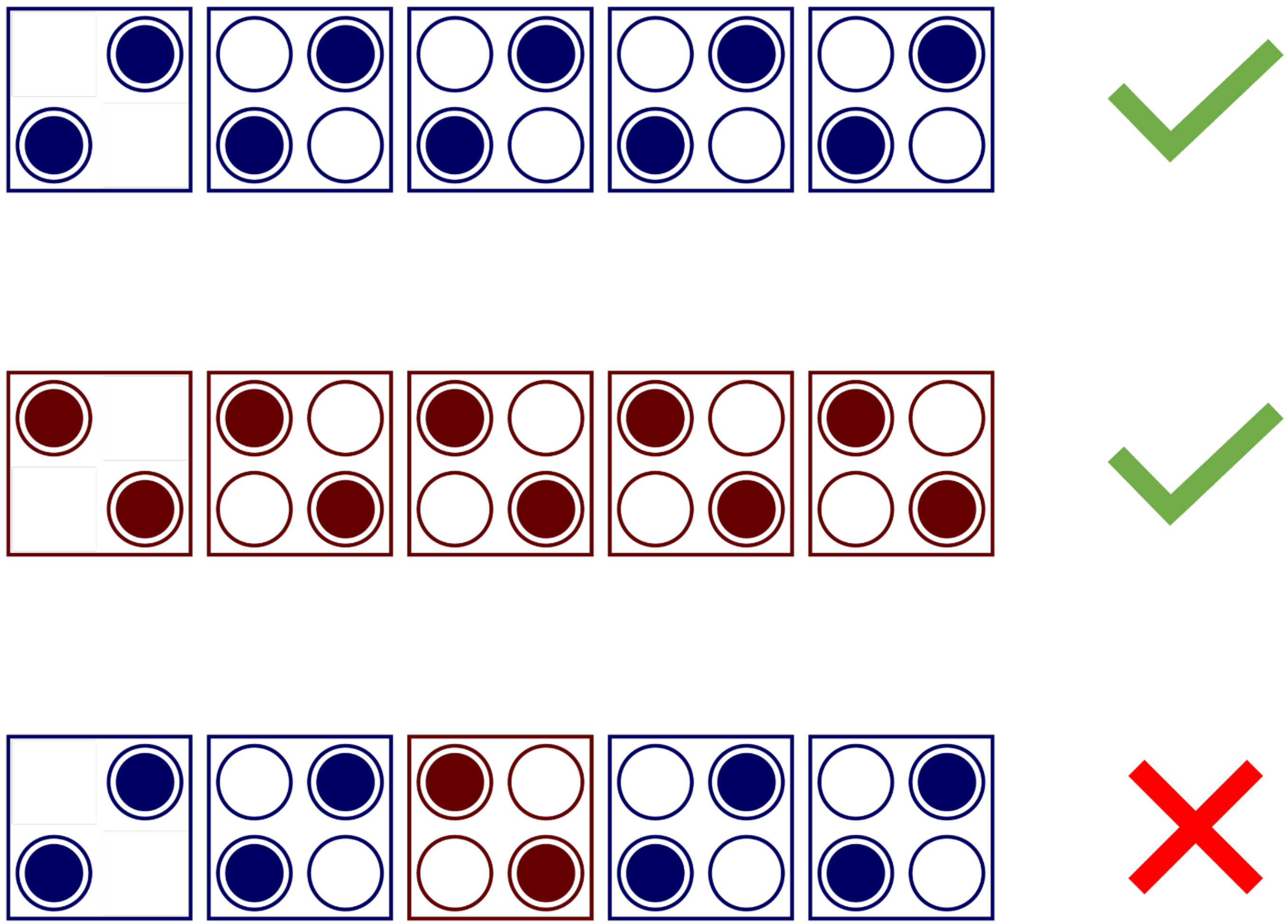
[1] Snider, 1999

QCA Wires



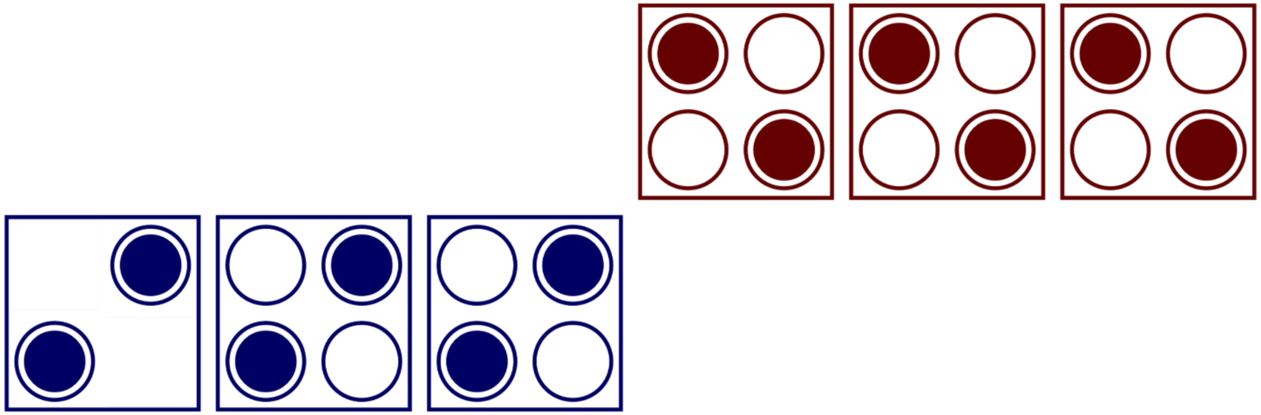
[1] Snider, 1999

QCA Wires



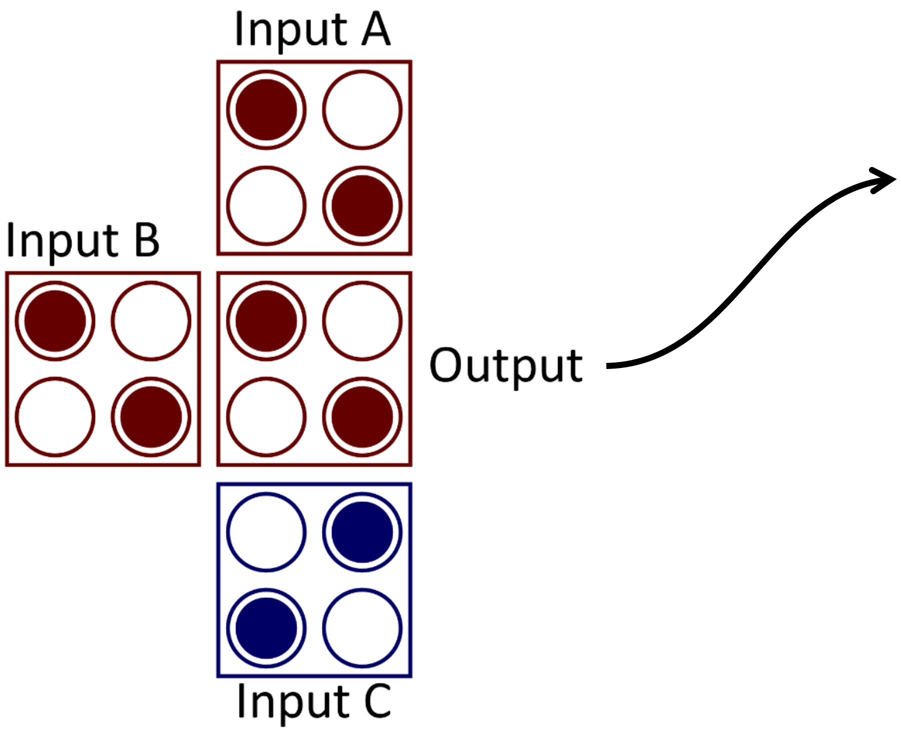
[1] Snider, 1999

QCA Inverter



[1] Snider, 1999

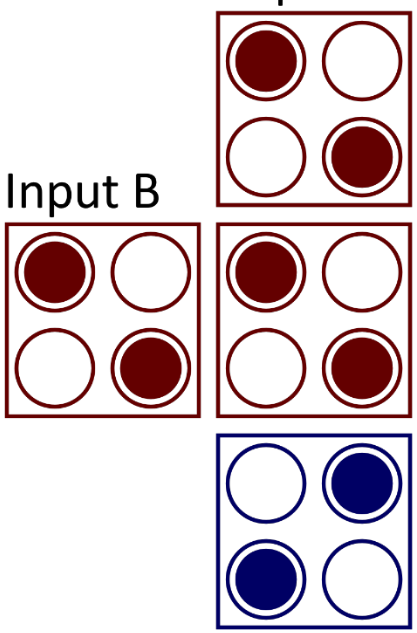
QCA Majority Gate



A	B	C	Out
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

[1] Snider, 1999

QCA Majority Gate

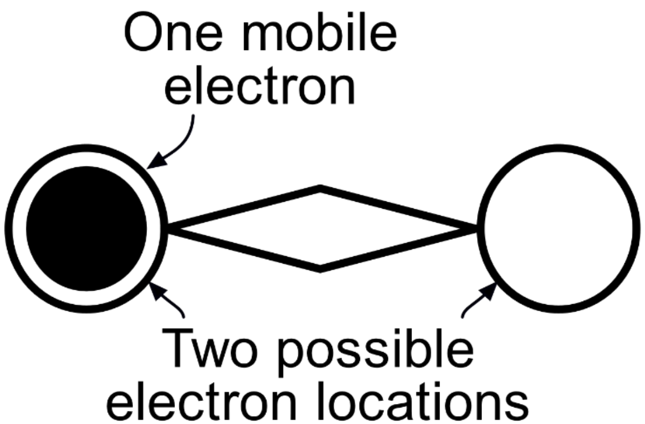


Program

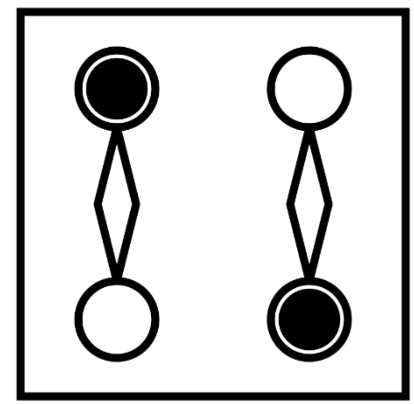
A	B	C	Out	
0	0	0	0	
0	0	1	0	AND
0	1	0	0	
0	1	1	1	
1	0	0	0	
1	0	1	1	OR
1	1	0	1	
1	1	1	1	

[1] Snider, 1999

Molecular Quantum Dot Cellular Automata



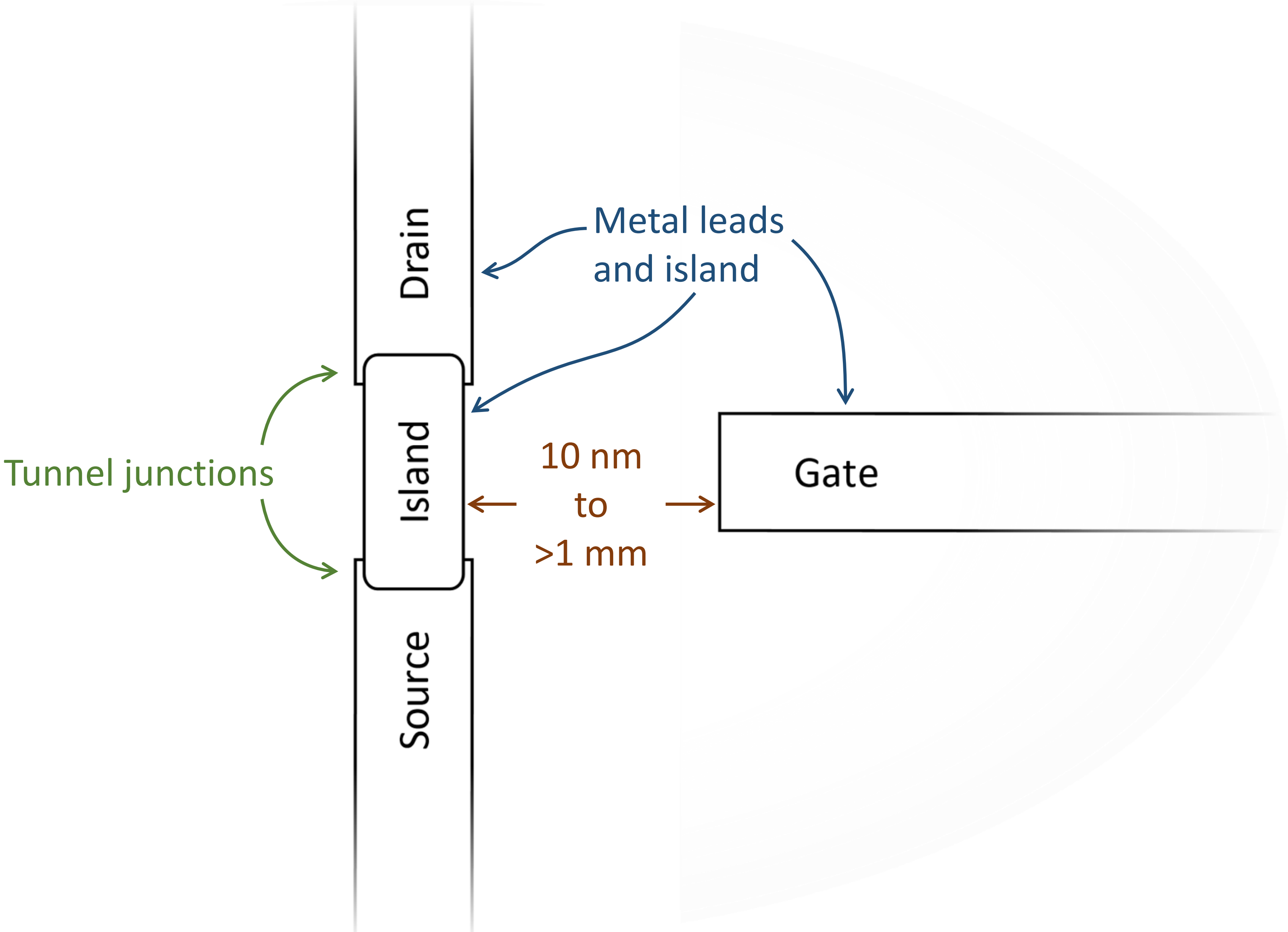
Mixed-Valence Molecule



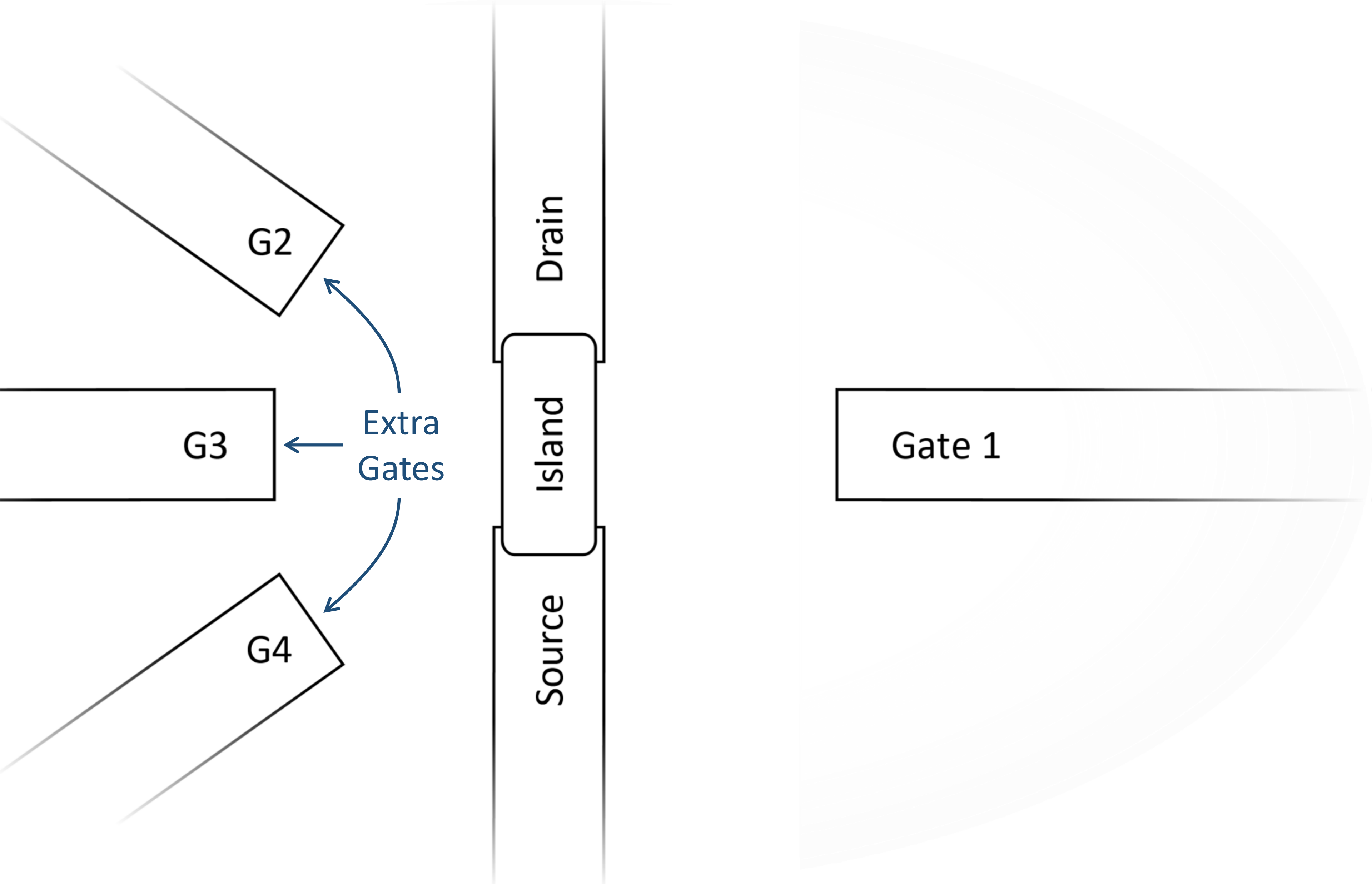
Two coupled mixed-valence molecules

[2] Lent, 2002

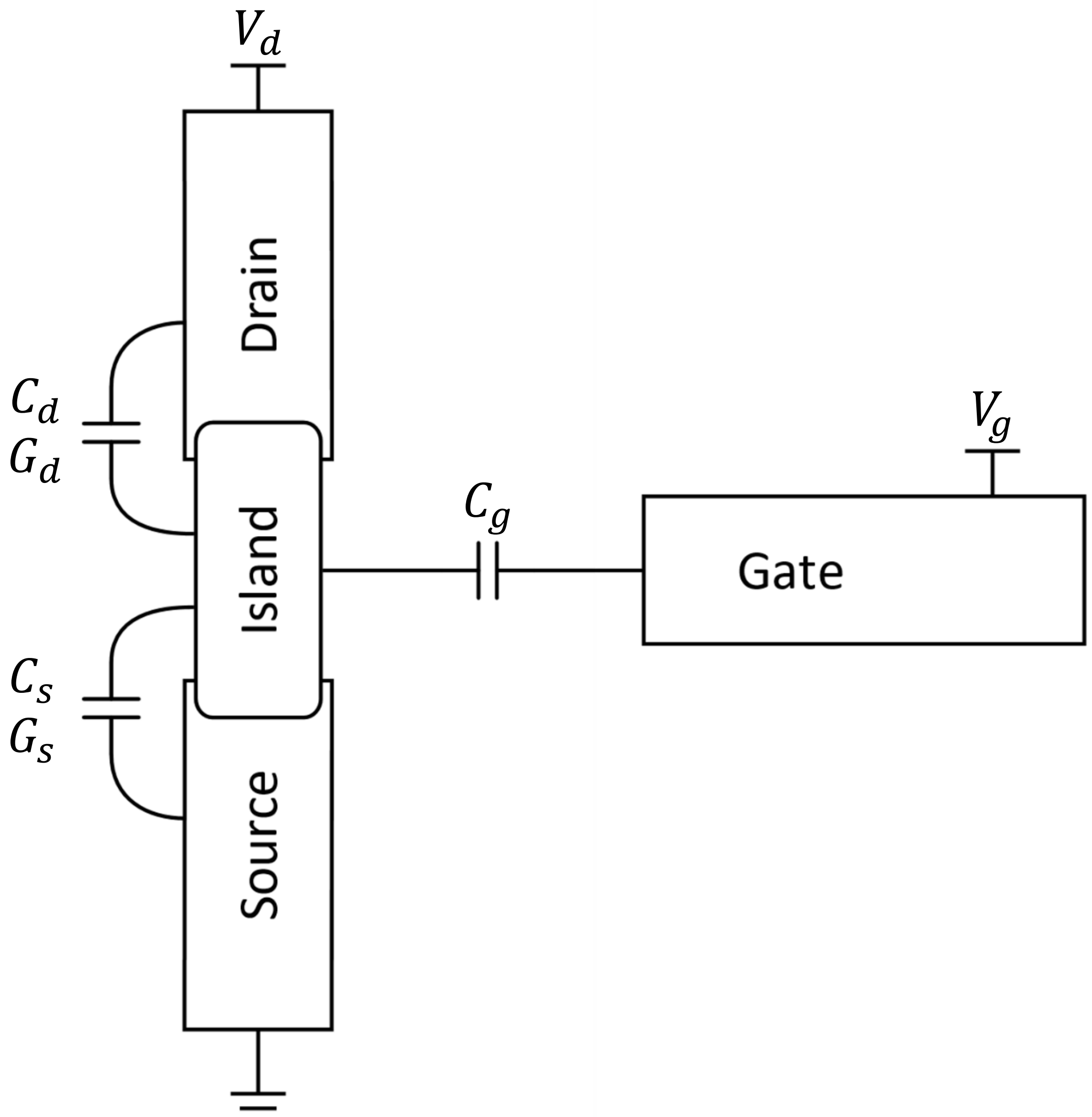
SET Structure



SET Structure



SET Structure



SET Island Potential

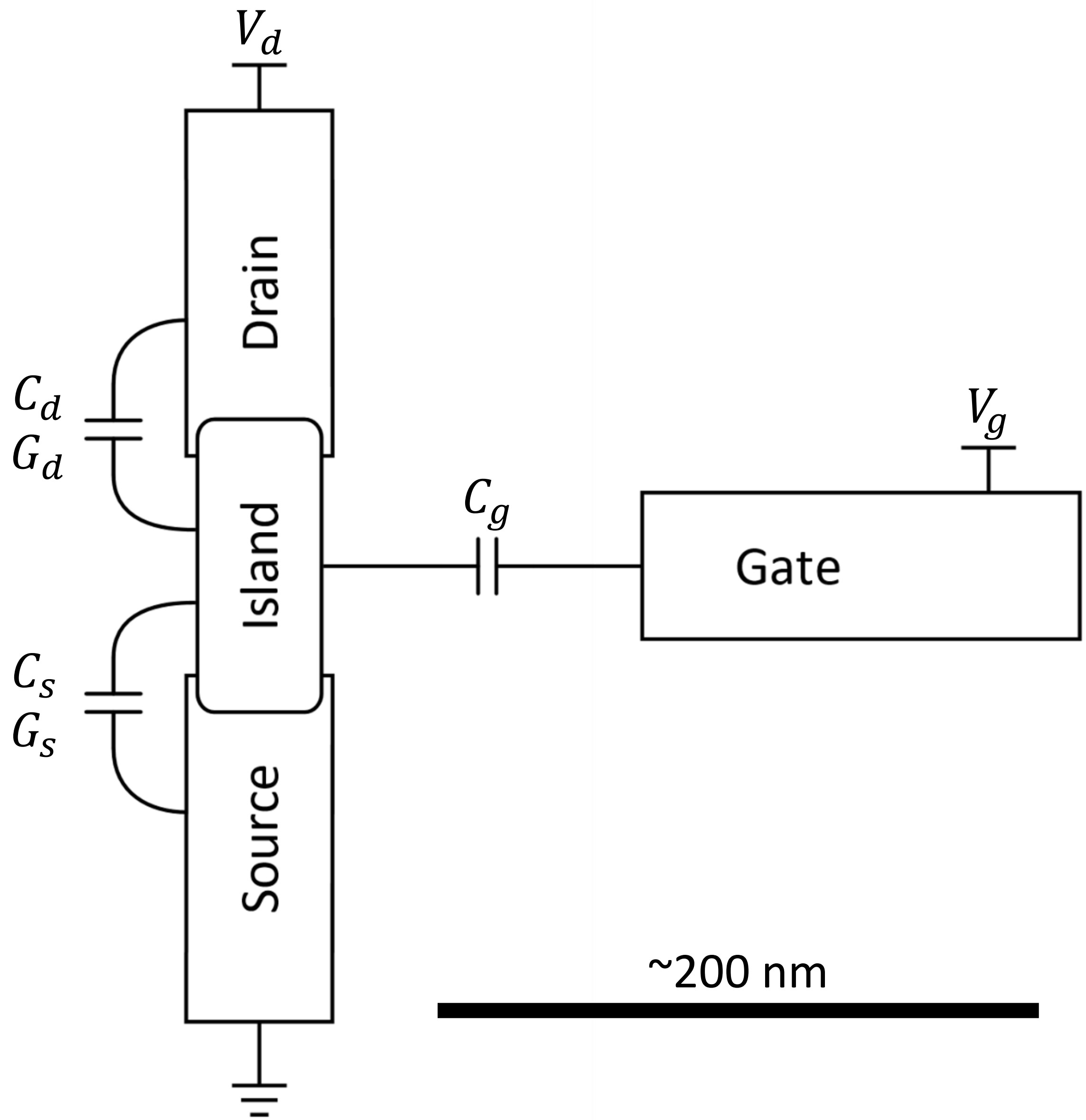
Total island capacitance

$$C_\Sigma = C_s + C_d + C_g$$

Electron charge

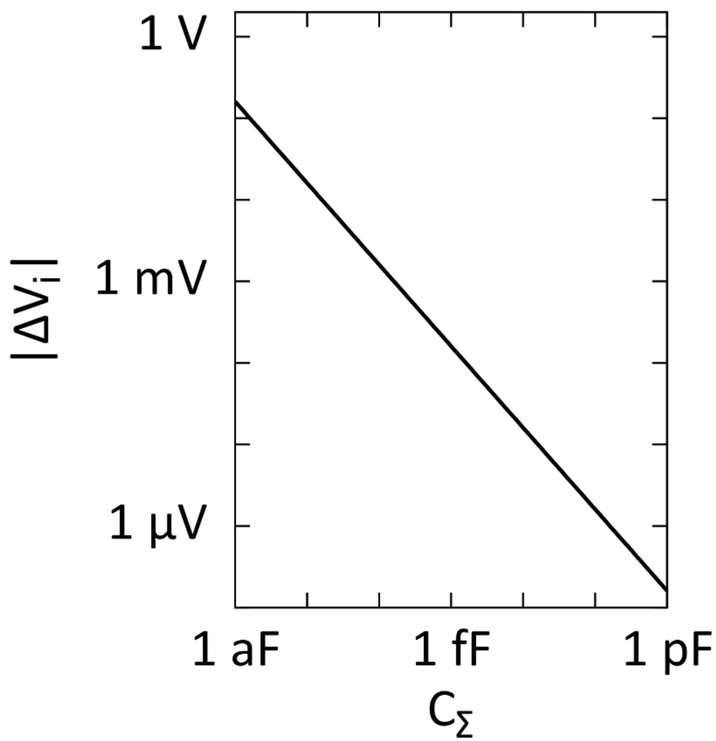
$$\Delta V_i = \frac{-e}{C_\Sigma}$$

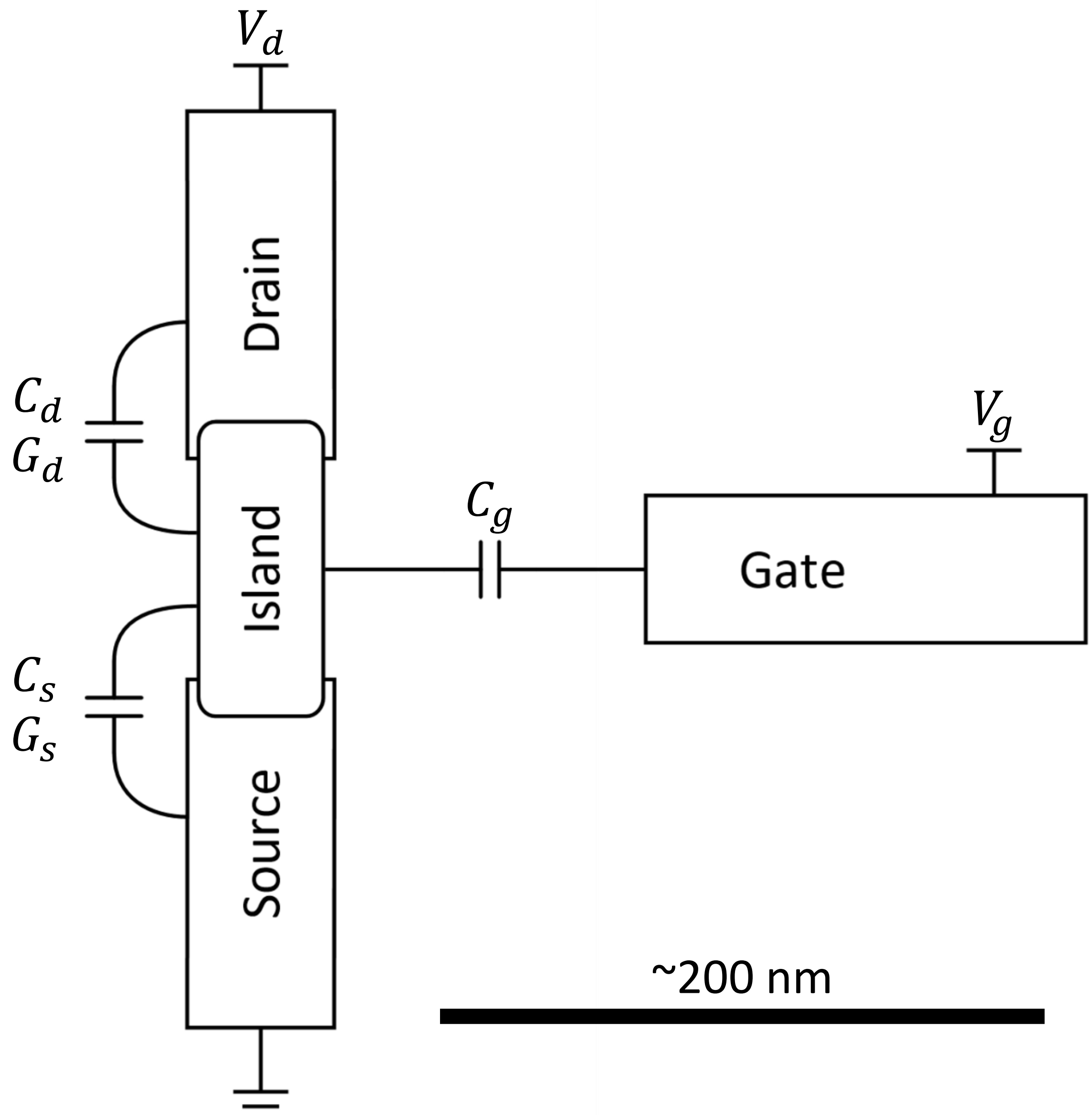
Change in island potential when an electron is added to the island



SET Island Potential

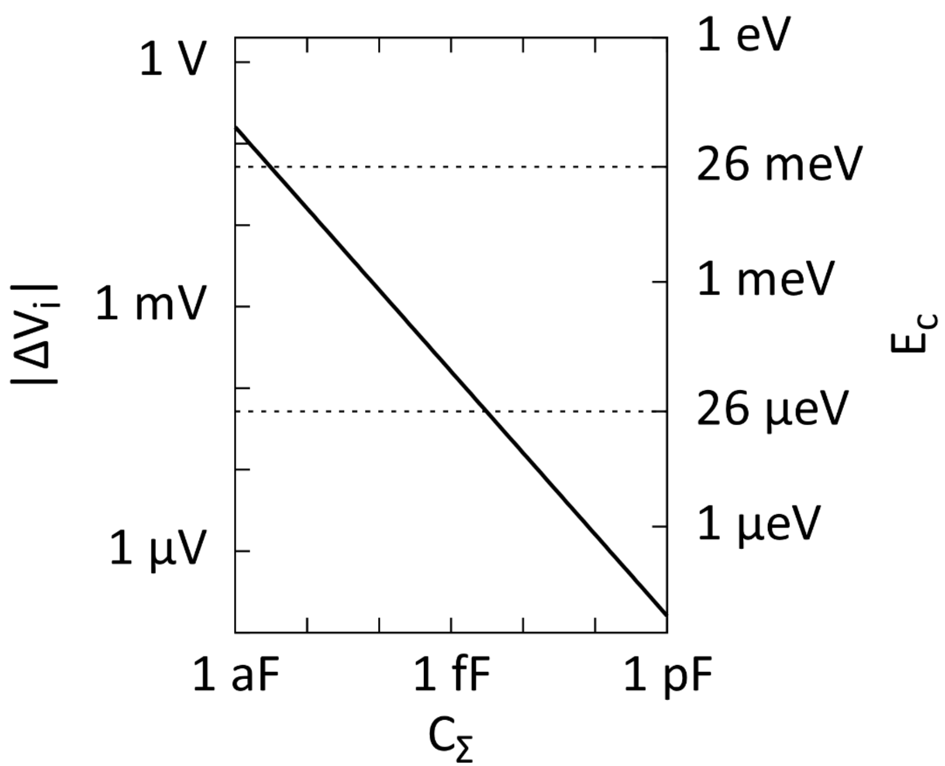
$$\Delta V_i = \frac{-e}{C_\Sigma}$$





SET Charging Energy

$$\Delta V_i = \frac{-e}{C_\Sigma}$$



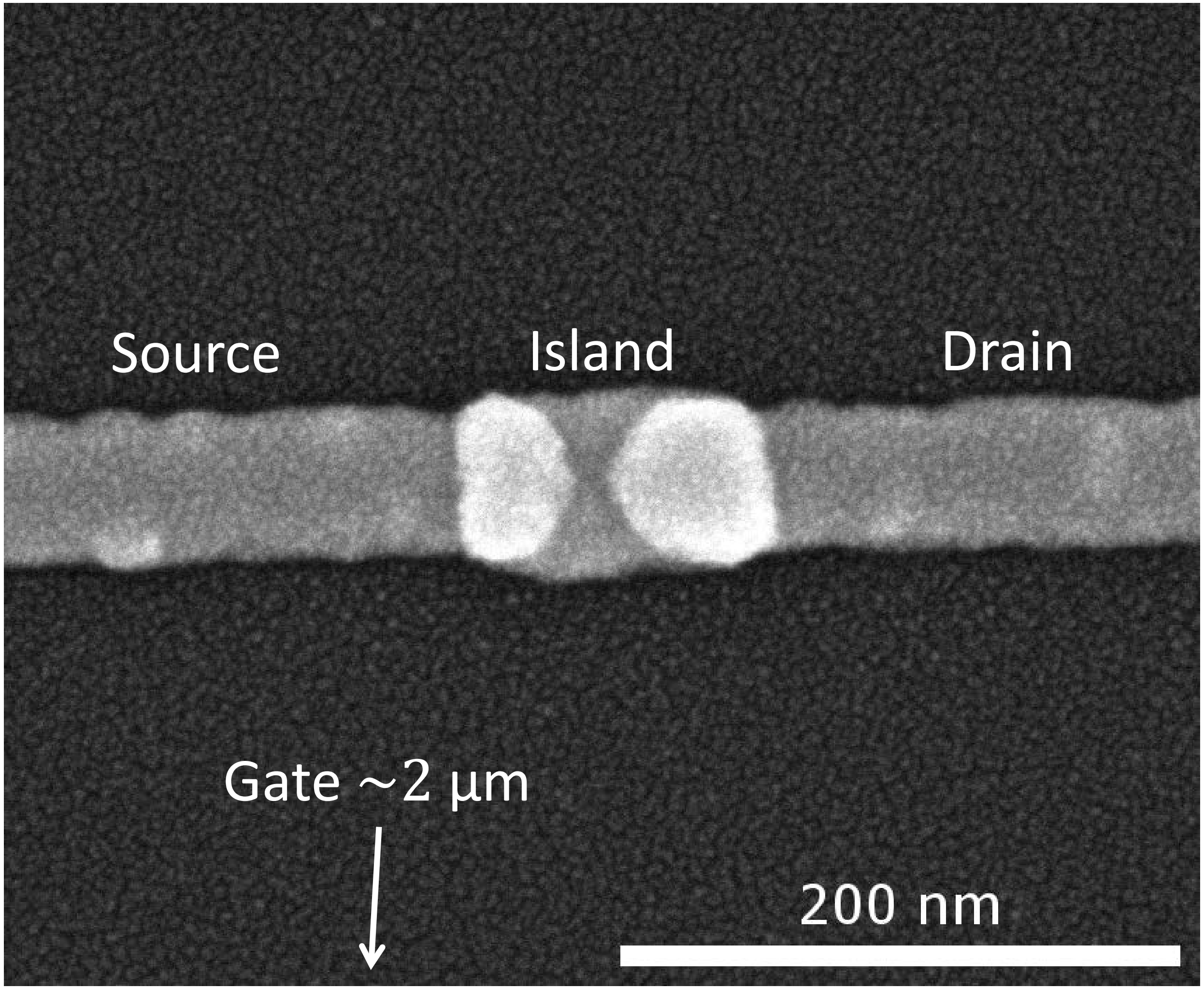
Energy stored in a capacitor

$$E_{cap} = \frac{1}{2} C V^2$$

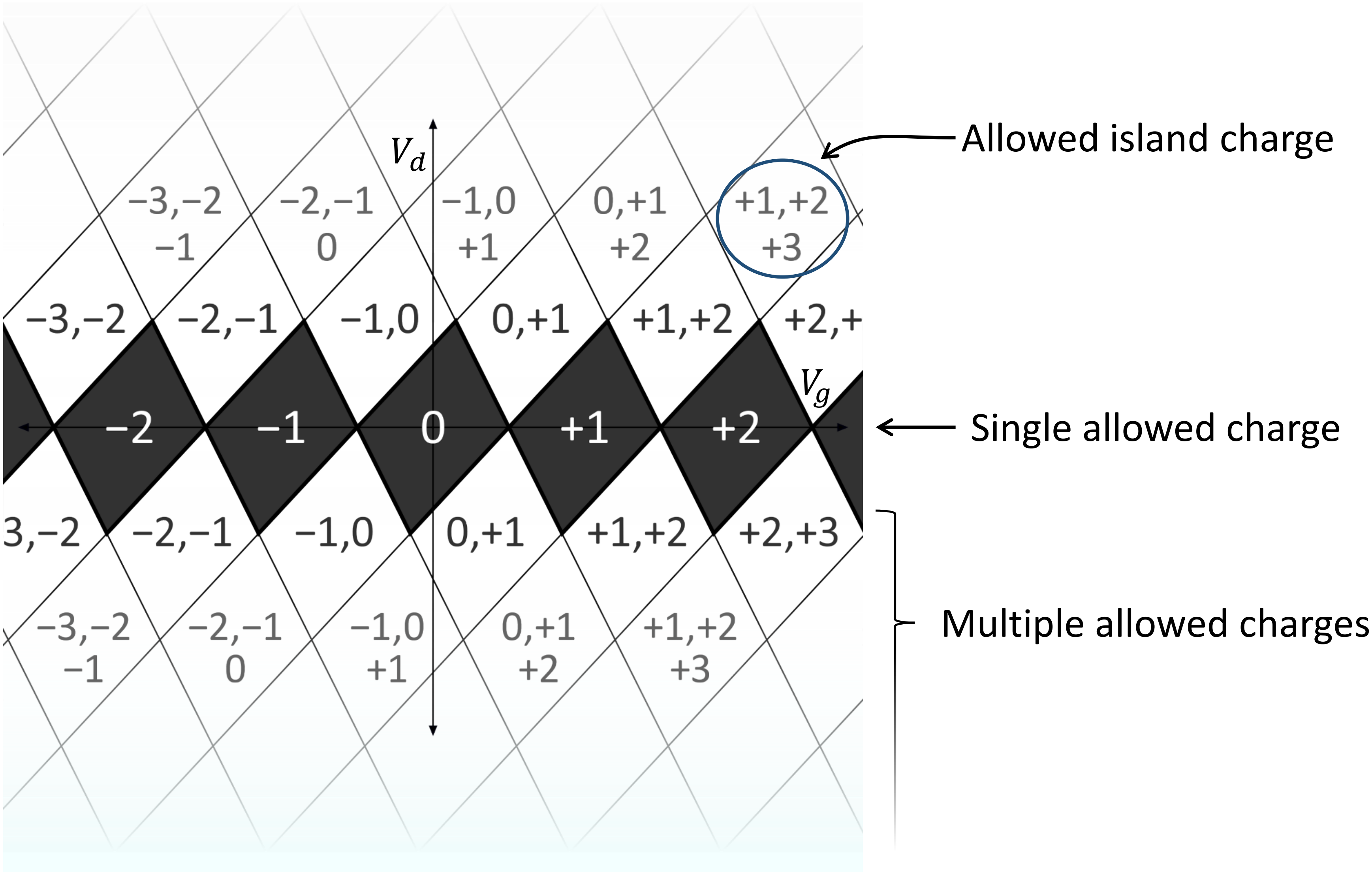
Charging energy of an SET

$$E_c = \frac{e^2}{2C_\Sigma}$$

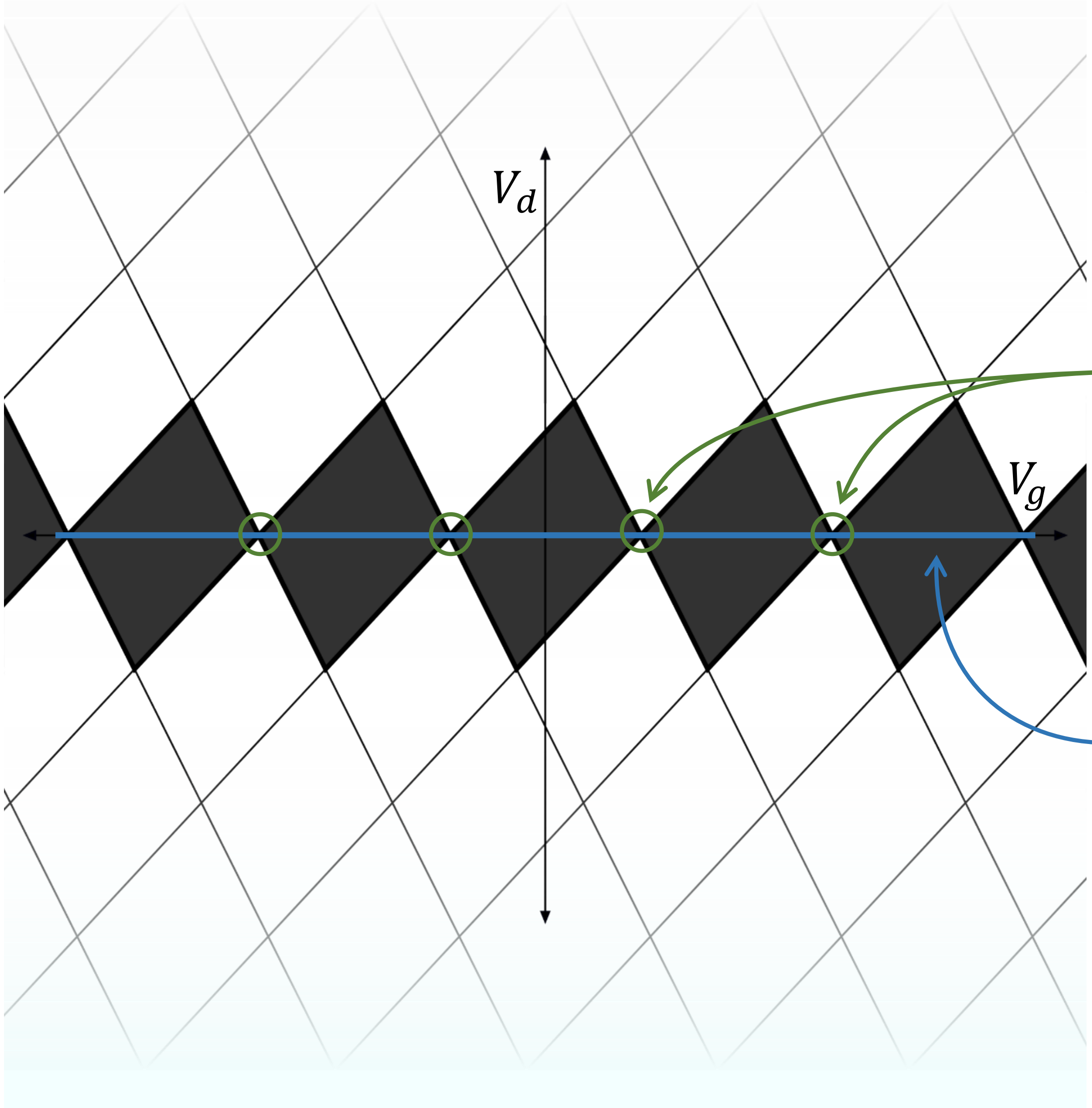
SET Structure



Charging Diagram at 0 K



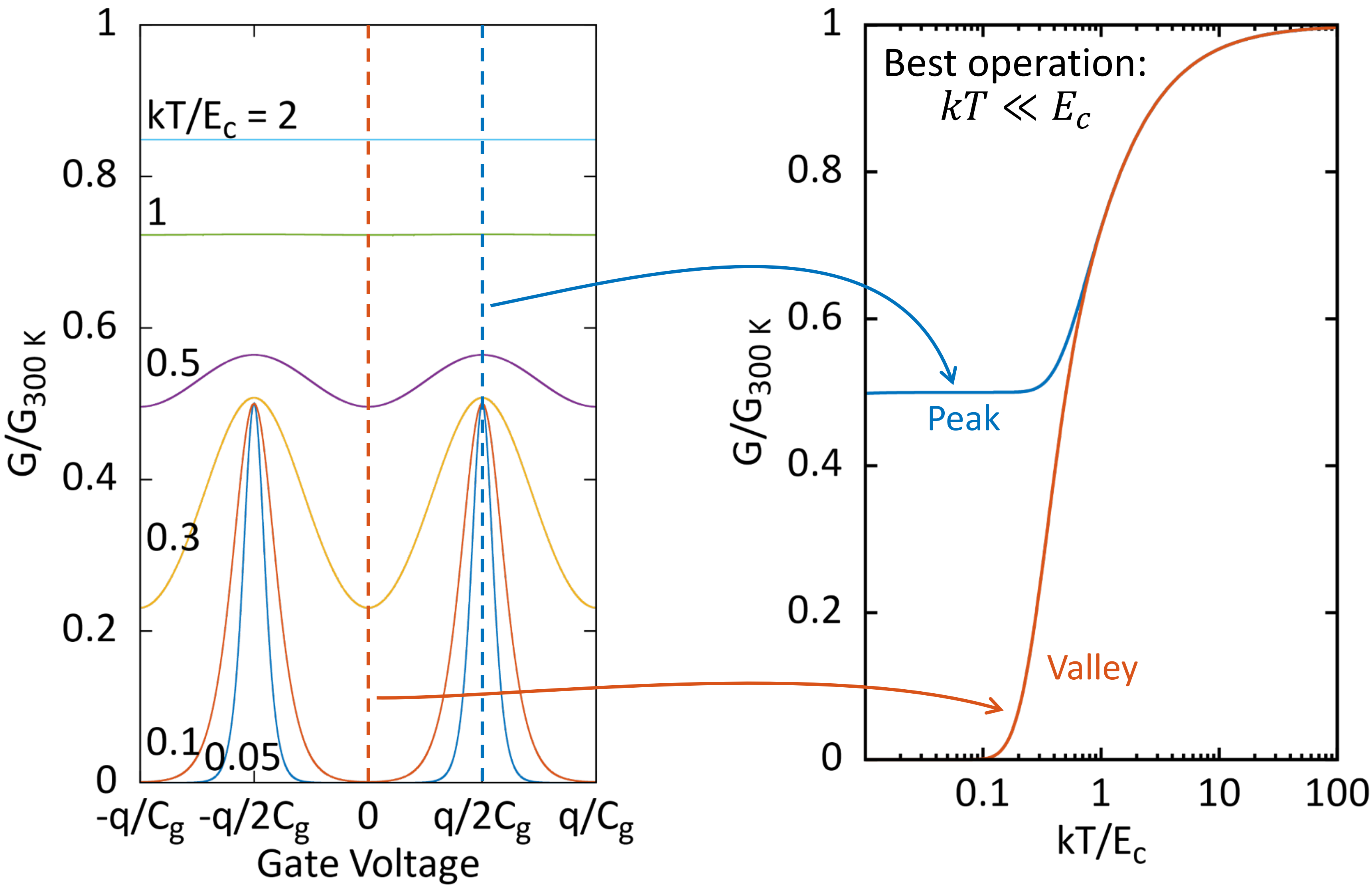
Charging Diagram at 0 K



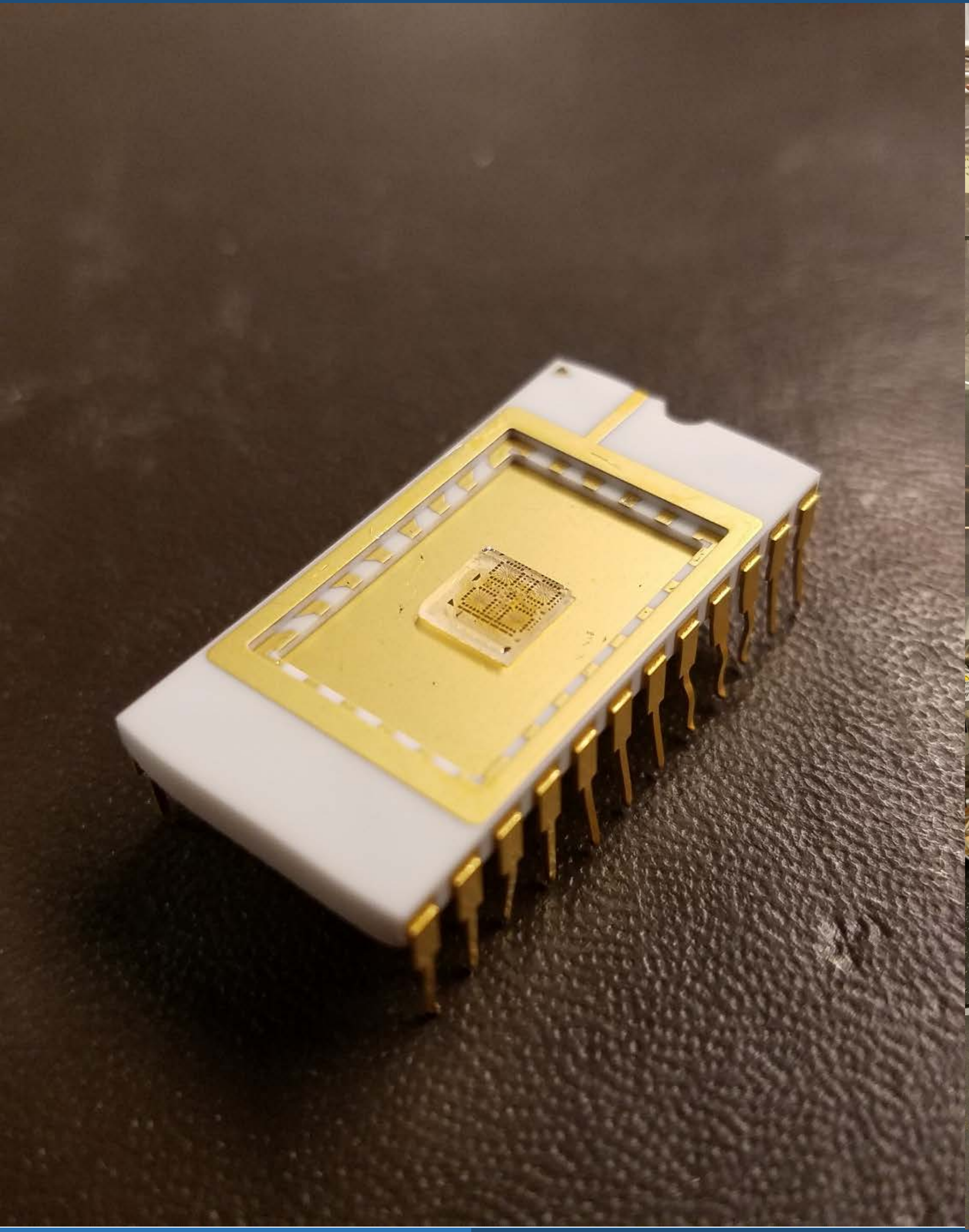
Peaks in Conductance

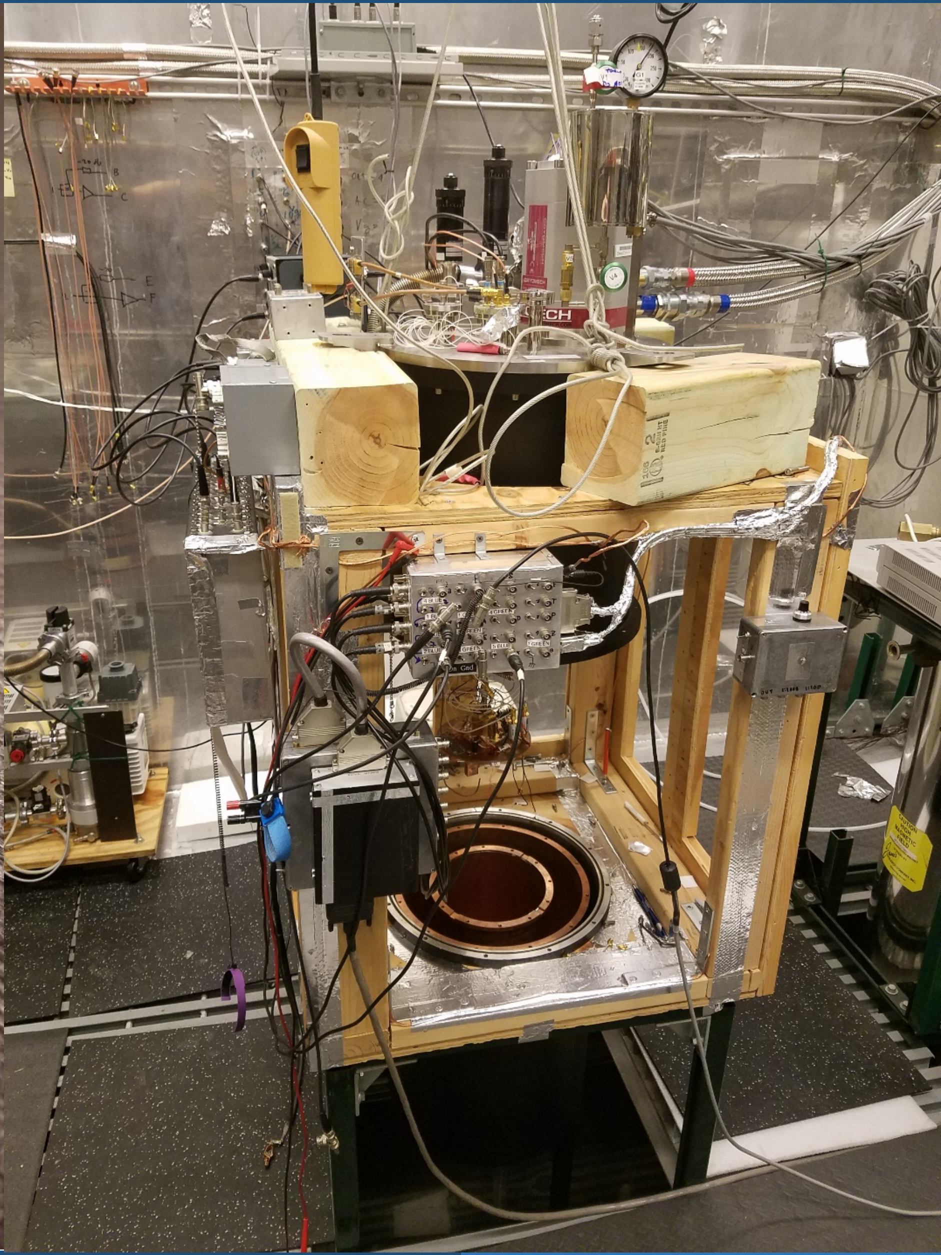
Coulomb Blockade Oscillations

Coulomb Blockade Oscillations

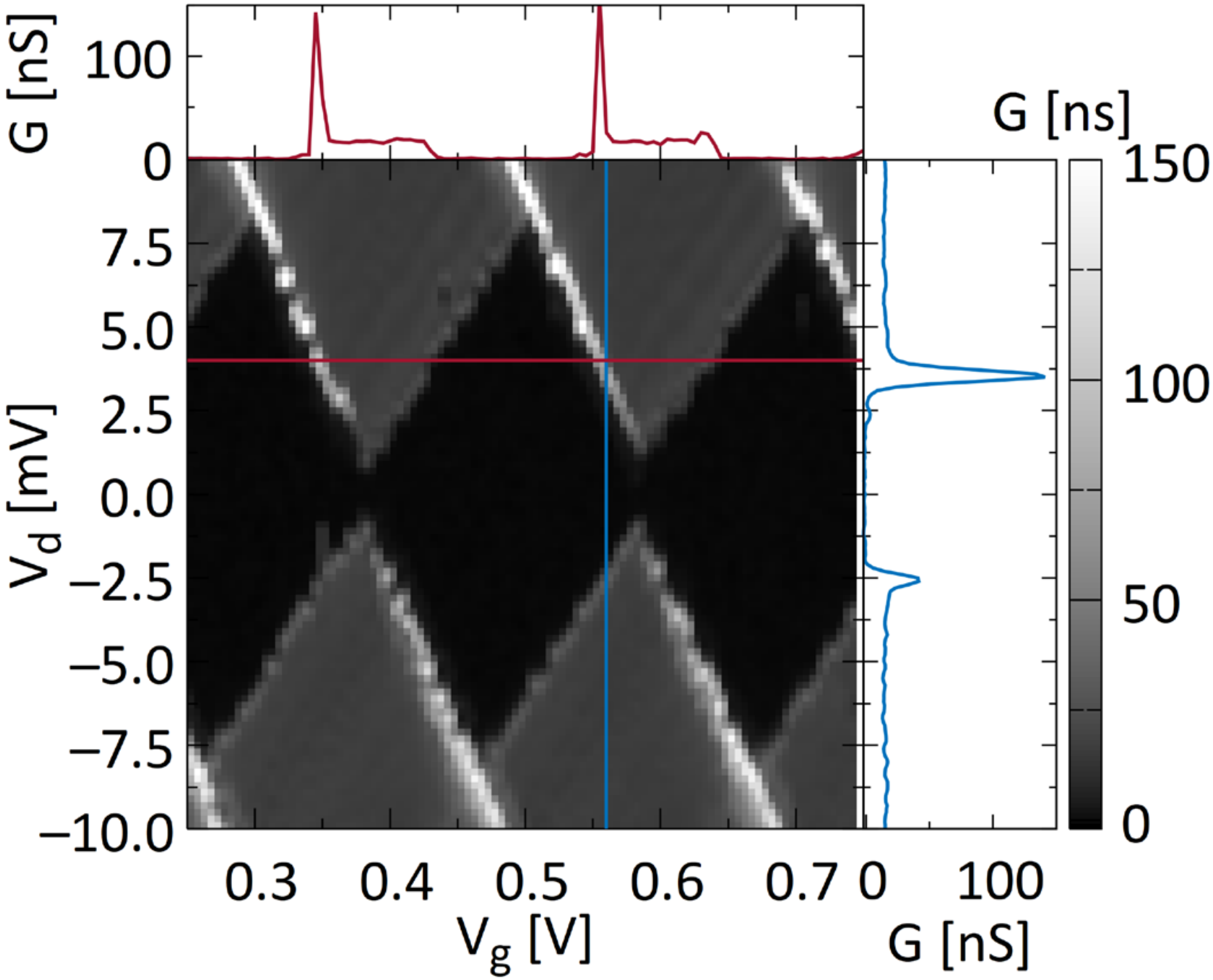


Measurement Setup

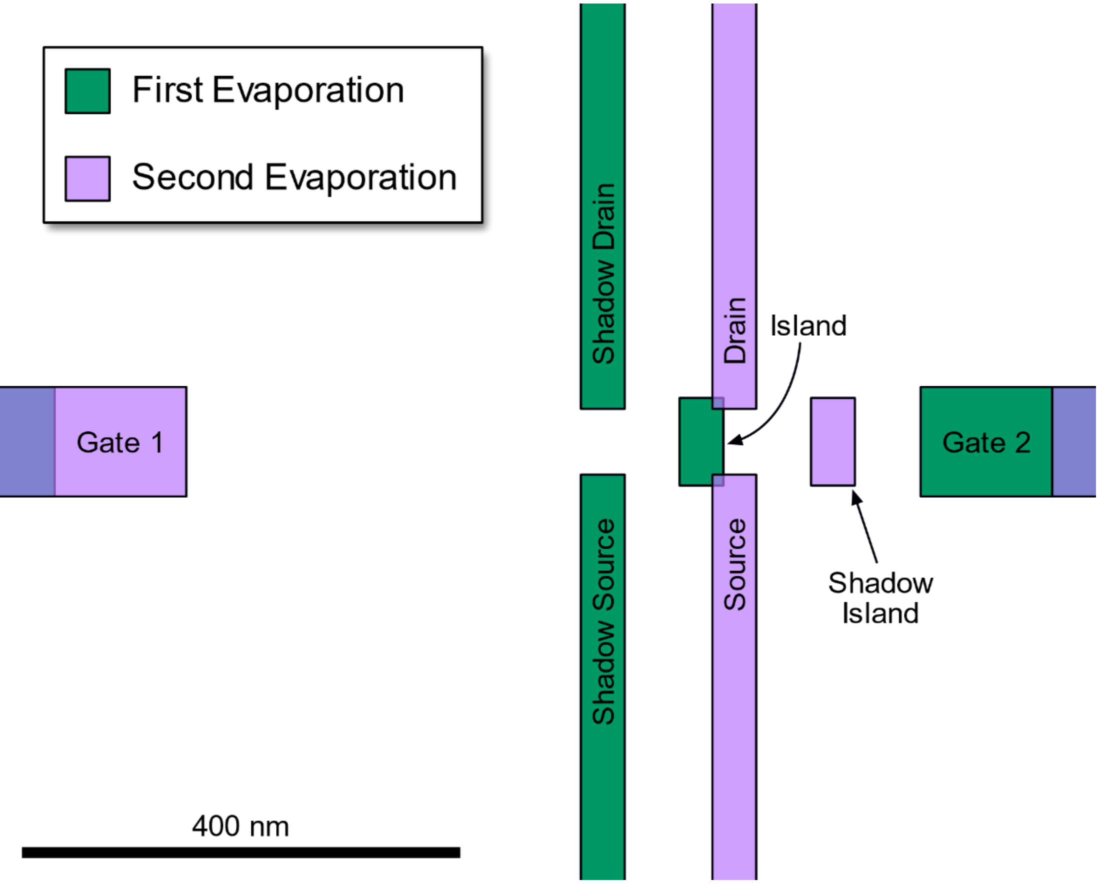


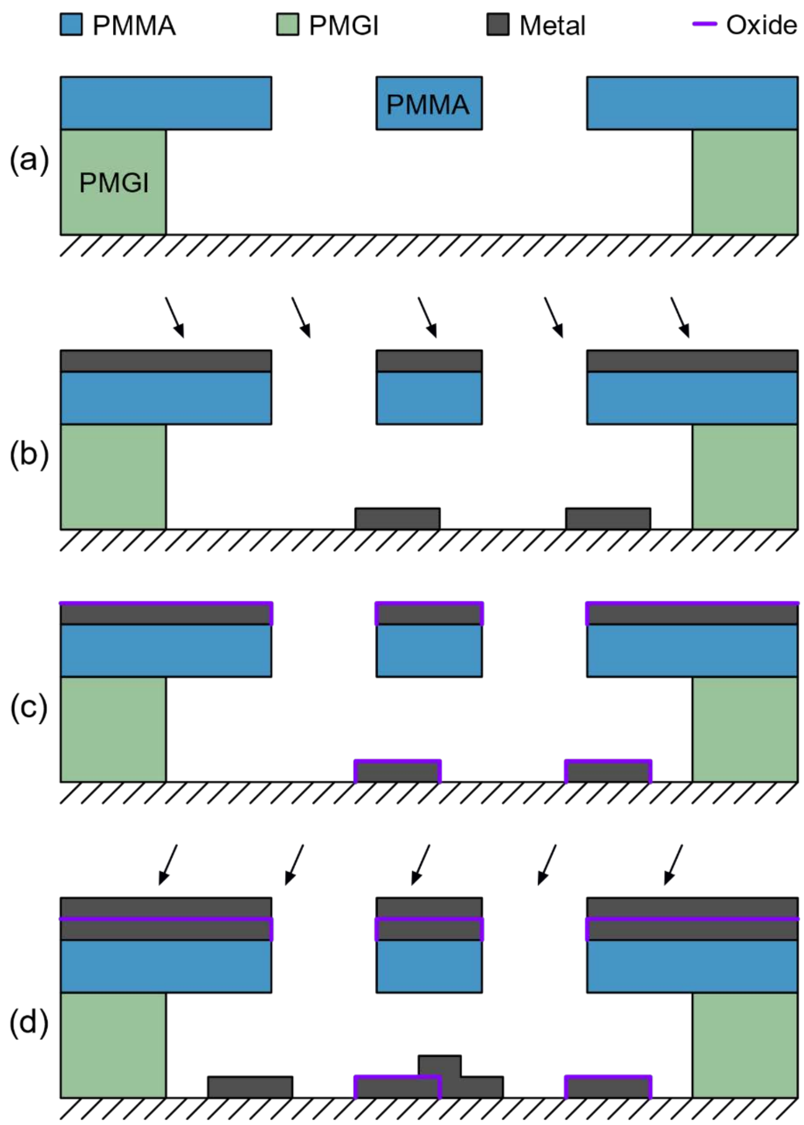


Measured SET at 300 mK

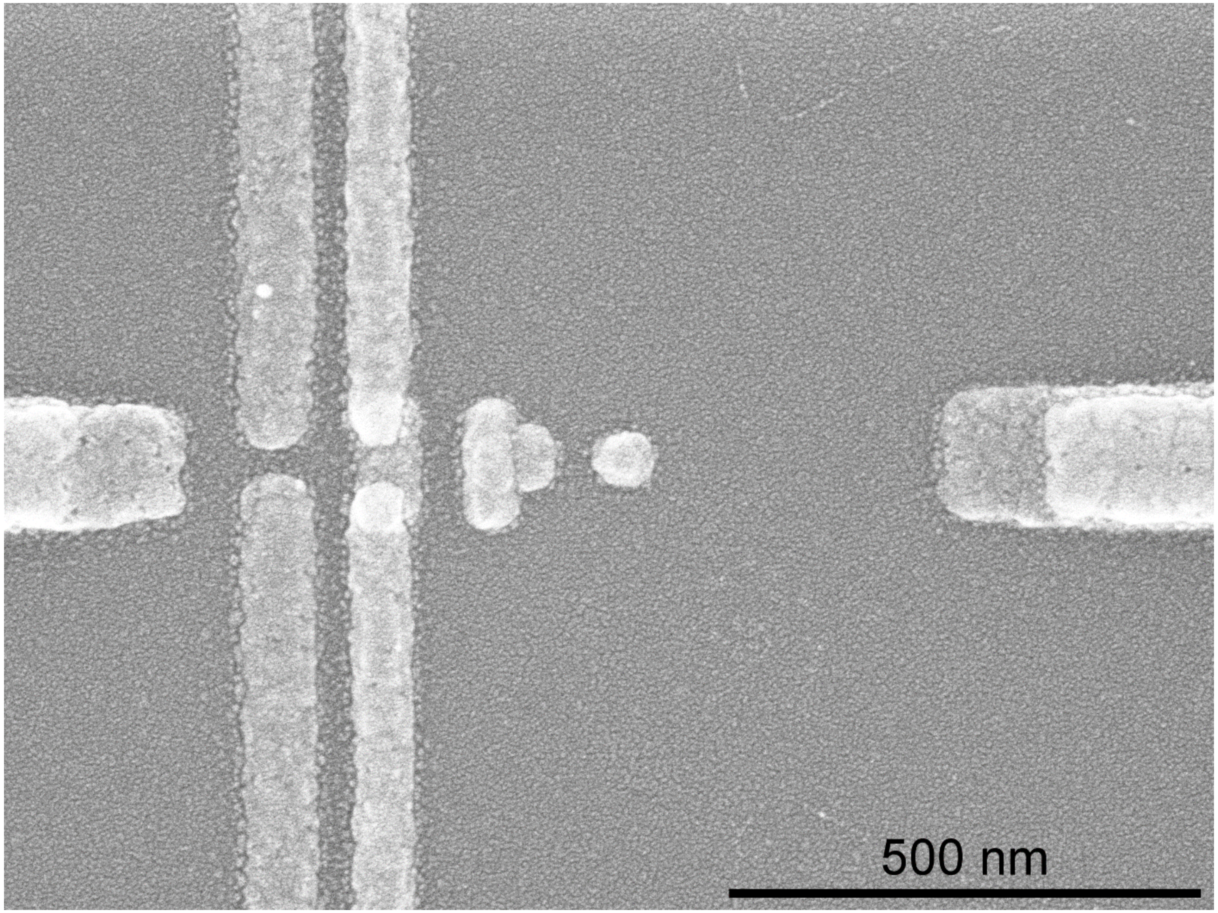


Dolan Bridge Process

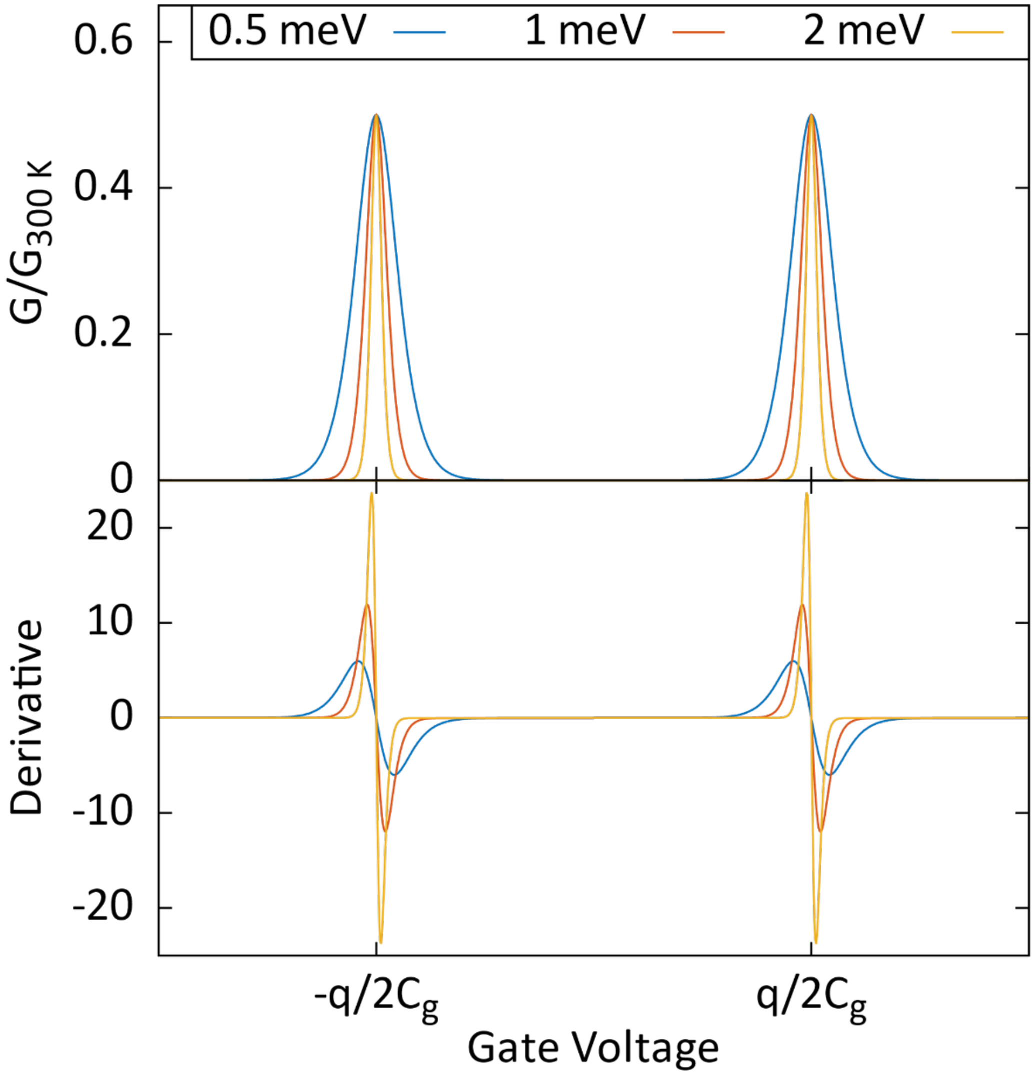




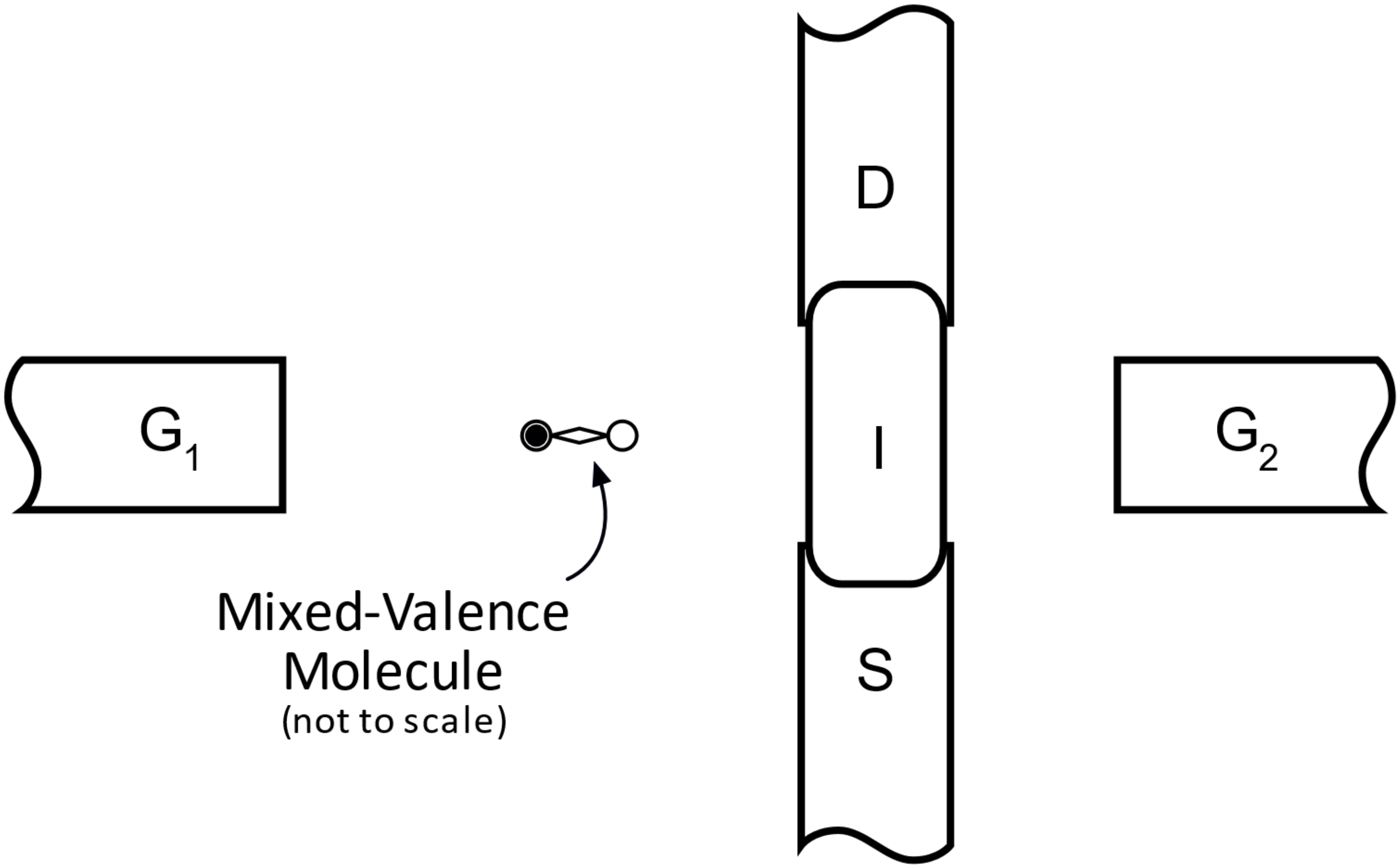
Dolan Bridge Process



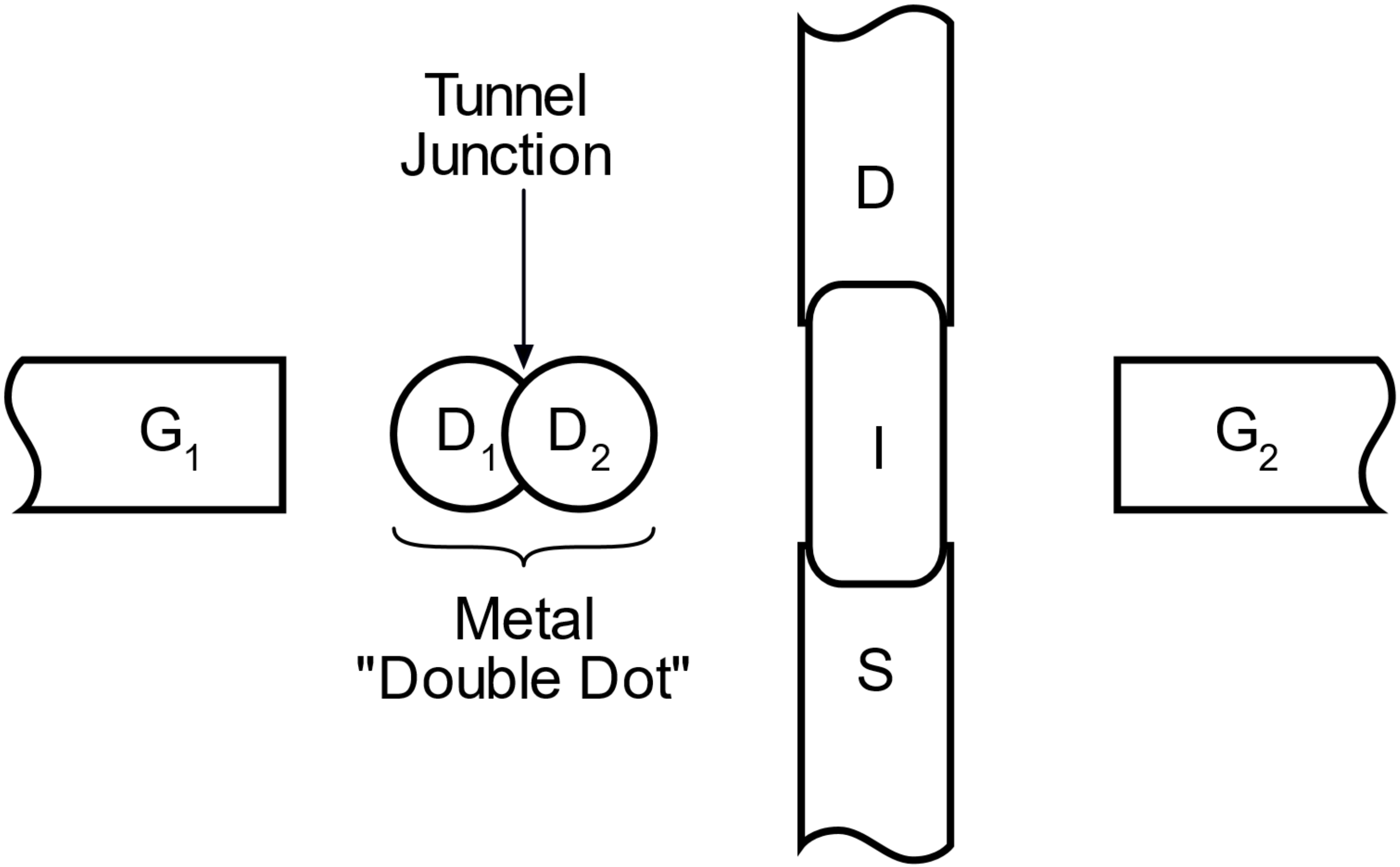
SET Charge Detector



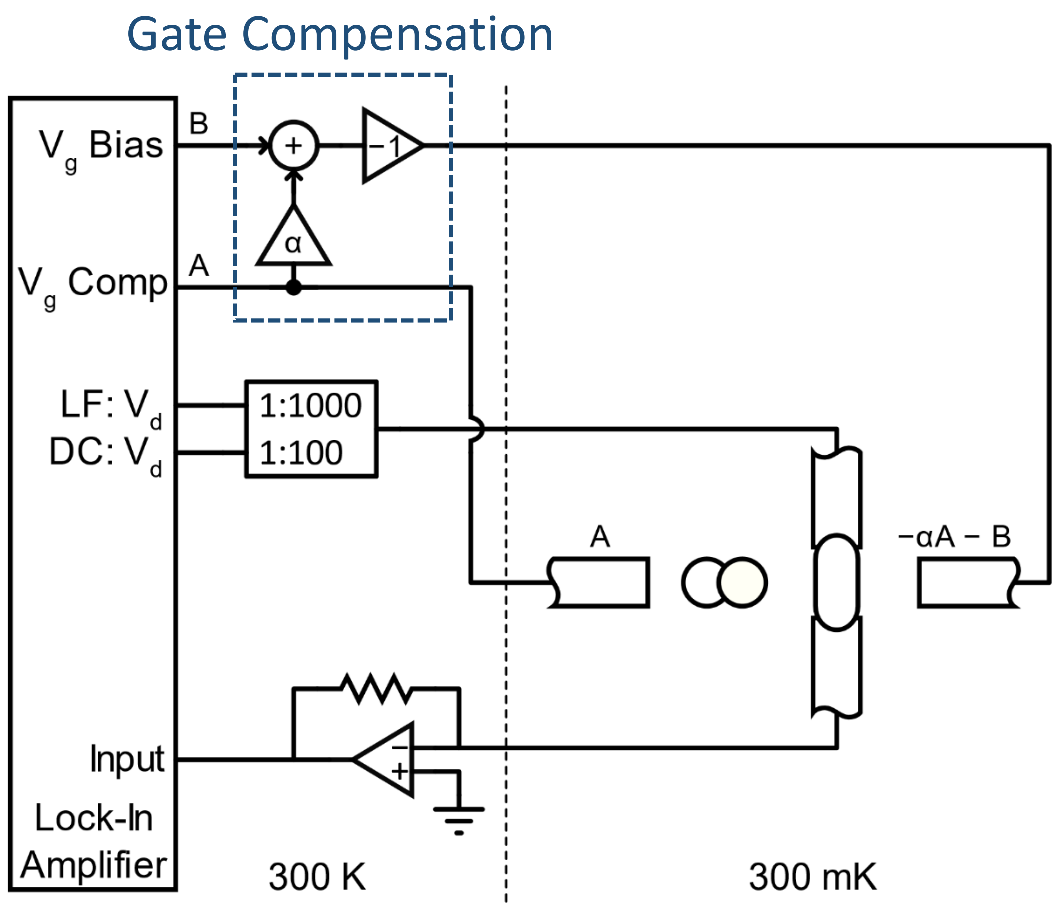
SET Charge Detector



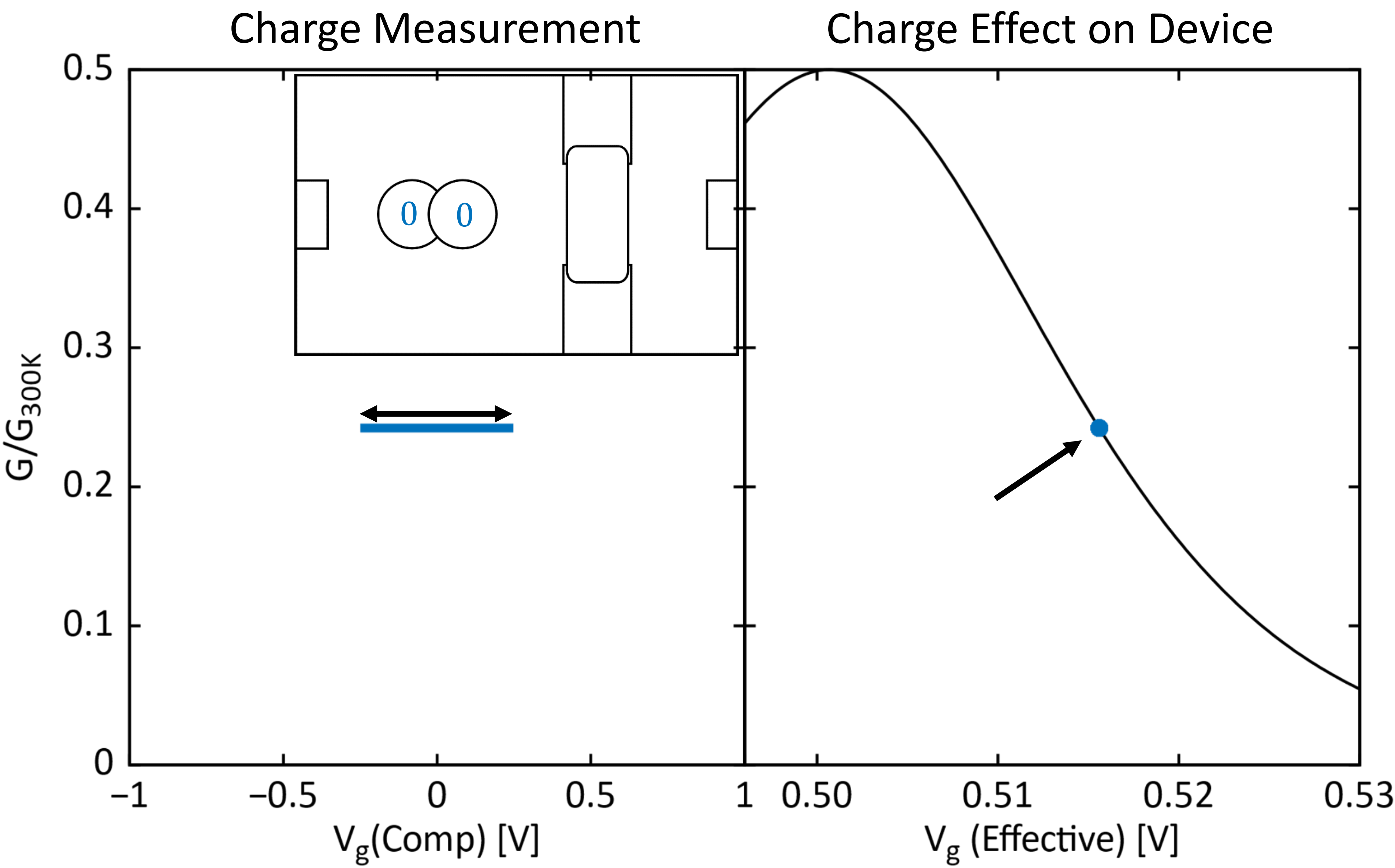
SET Charge Detector: Prototype Experiment



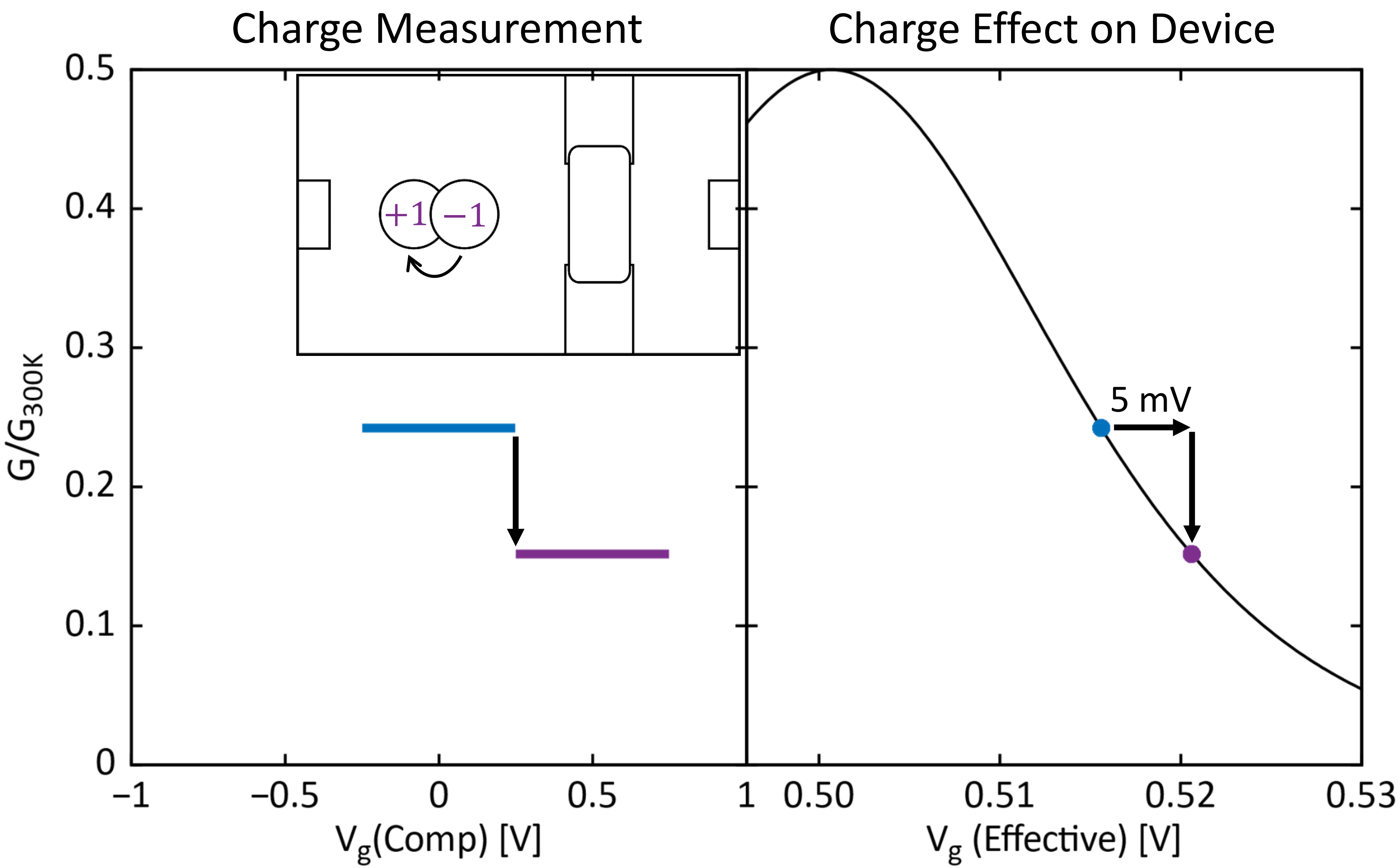
Compensated SET Measurement Setup



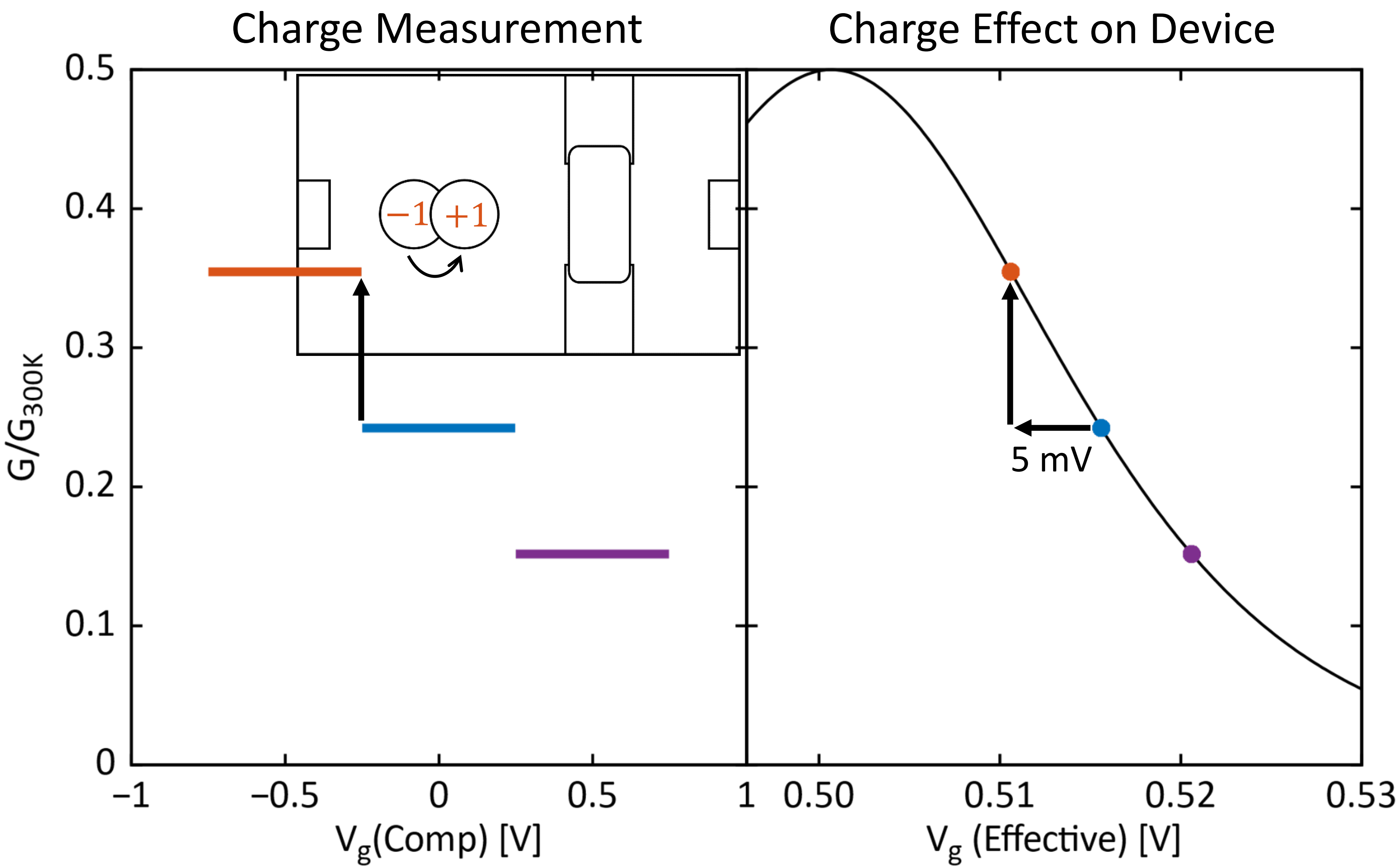
SET Charge Detector: 5 mV Signal



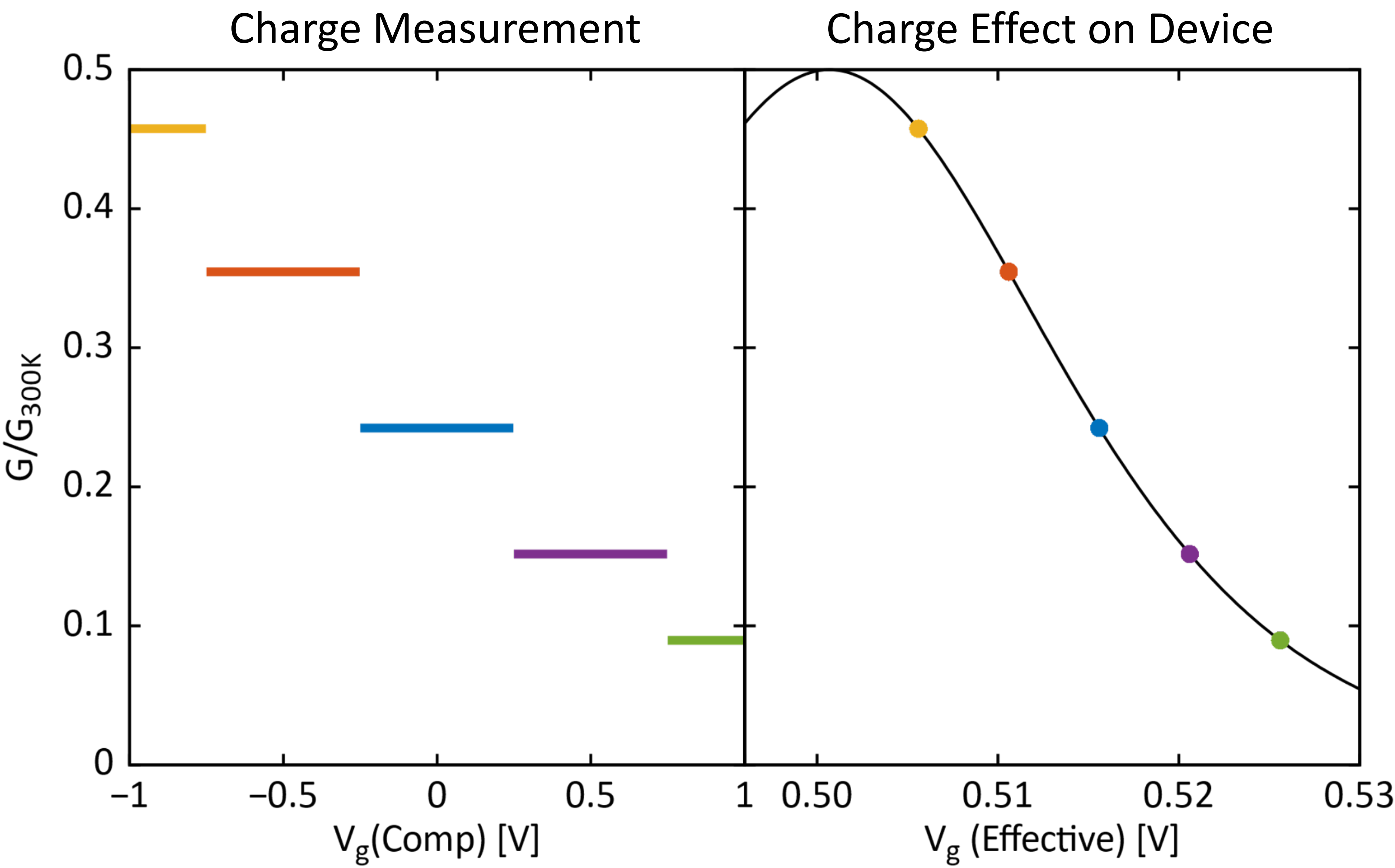
SET Charge Detector: 5 mV Signal



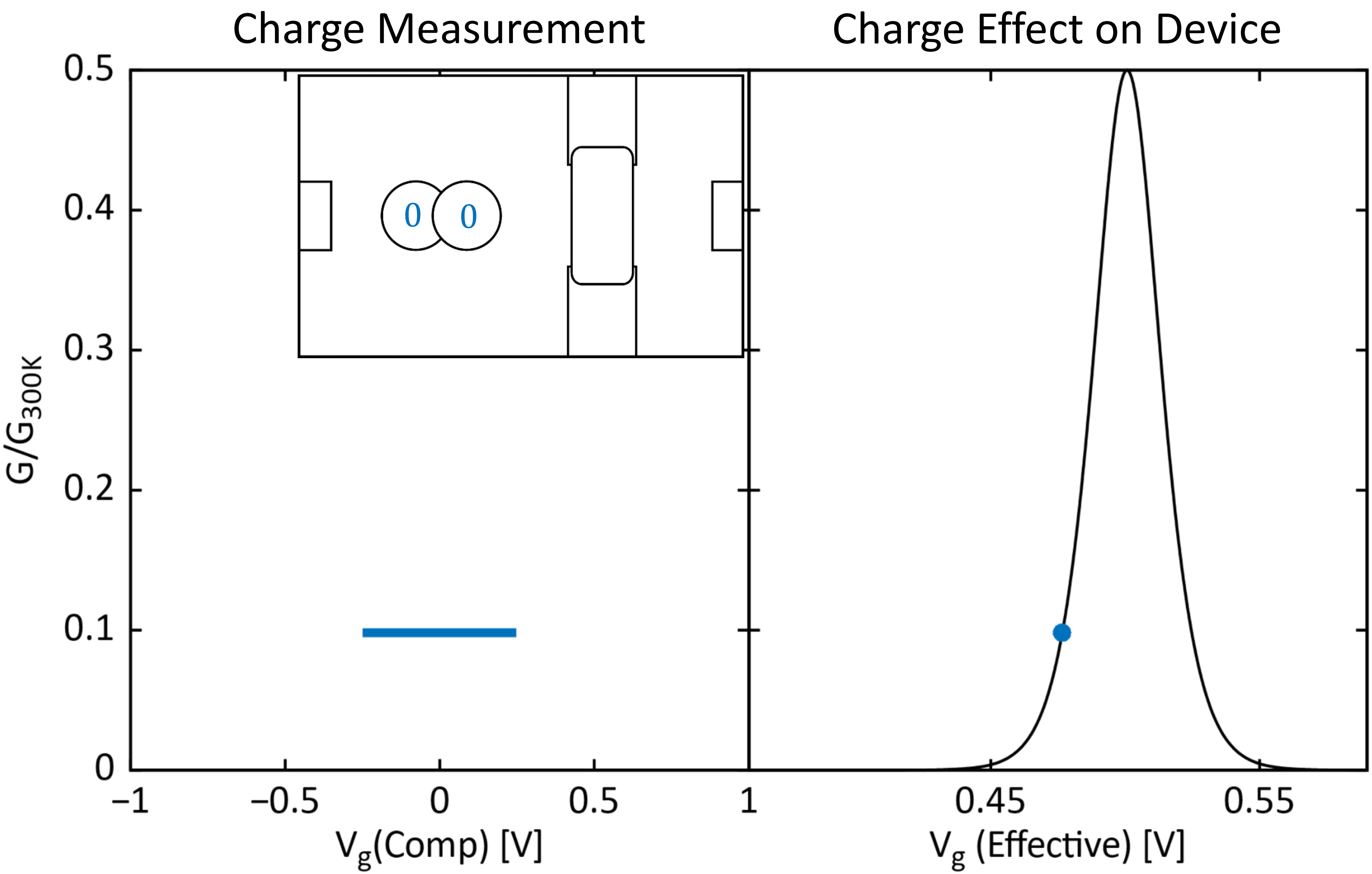
SET Charge Detector: 5 mV Signal



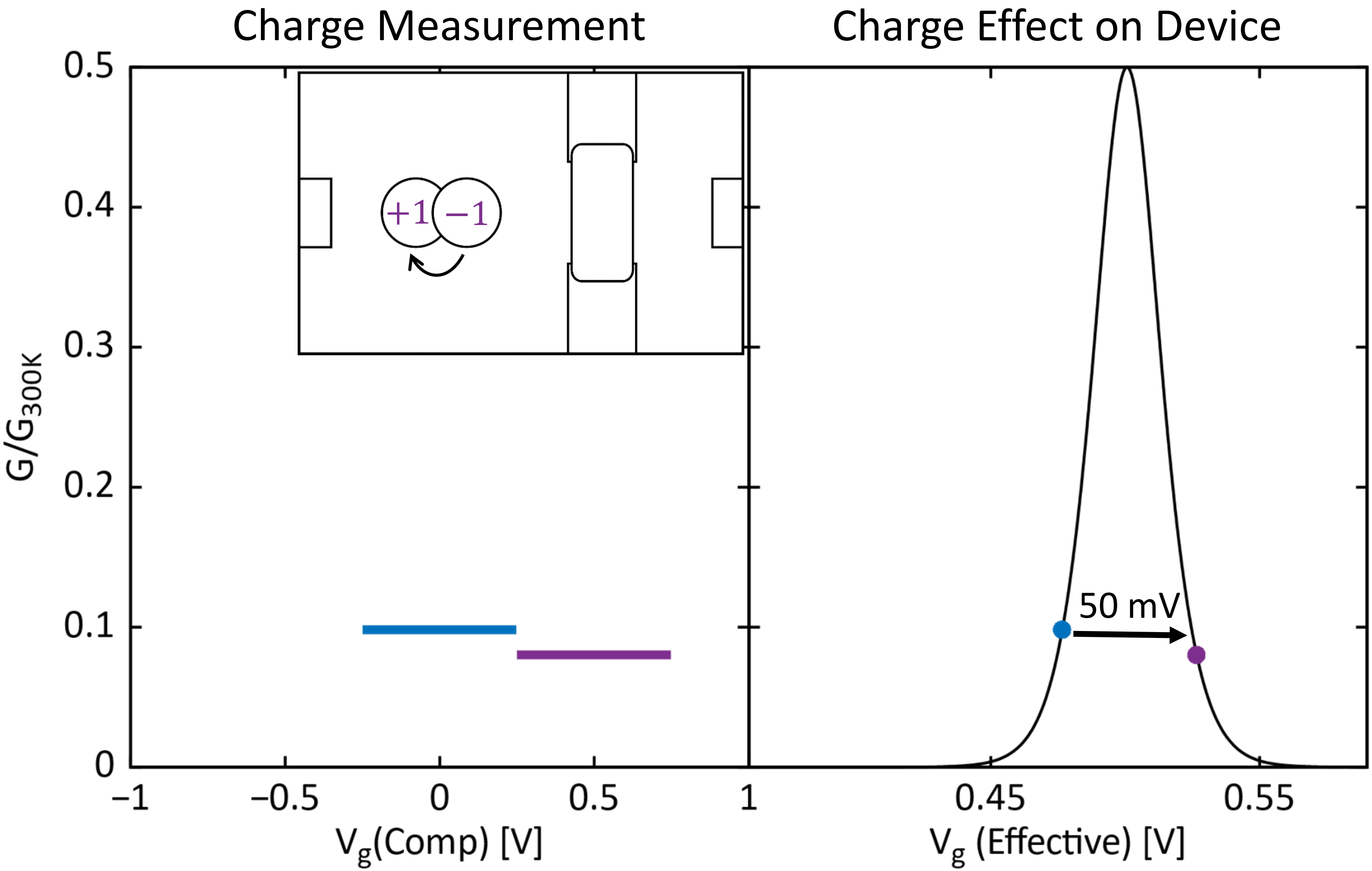
SET Charge Detector: 5 mV Signal



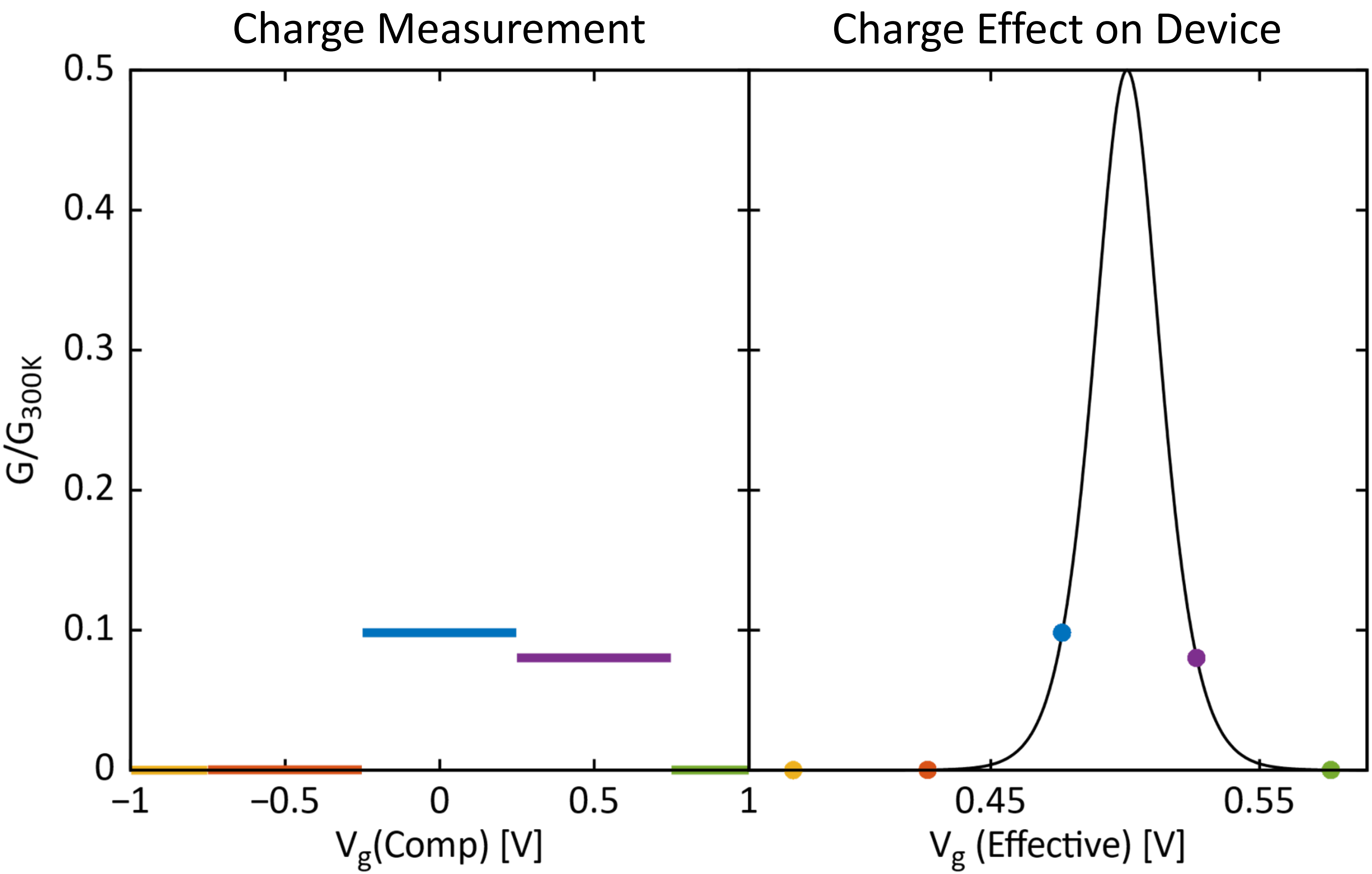
SET Charge Detector: 50 mV Signal



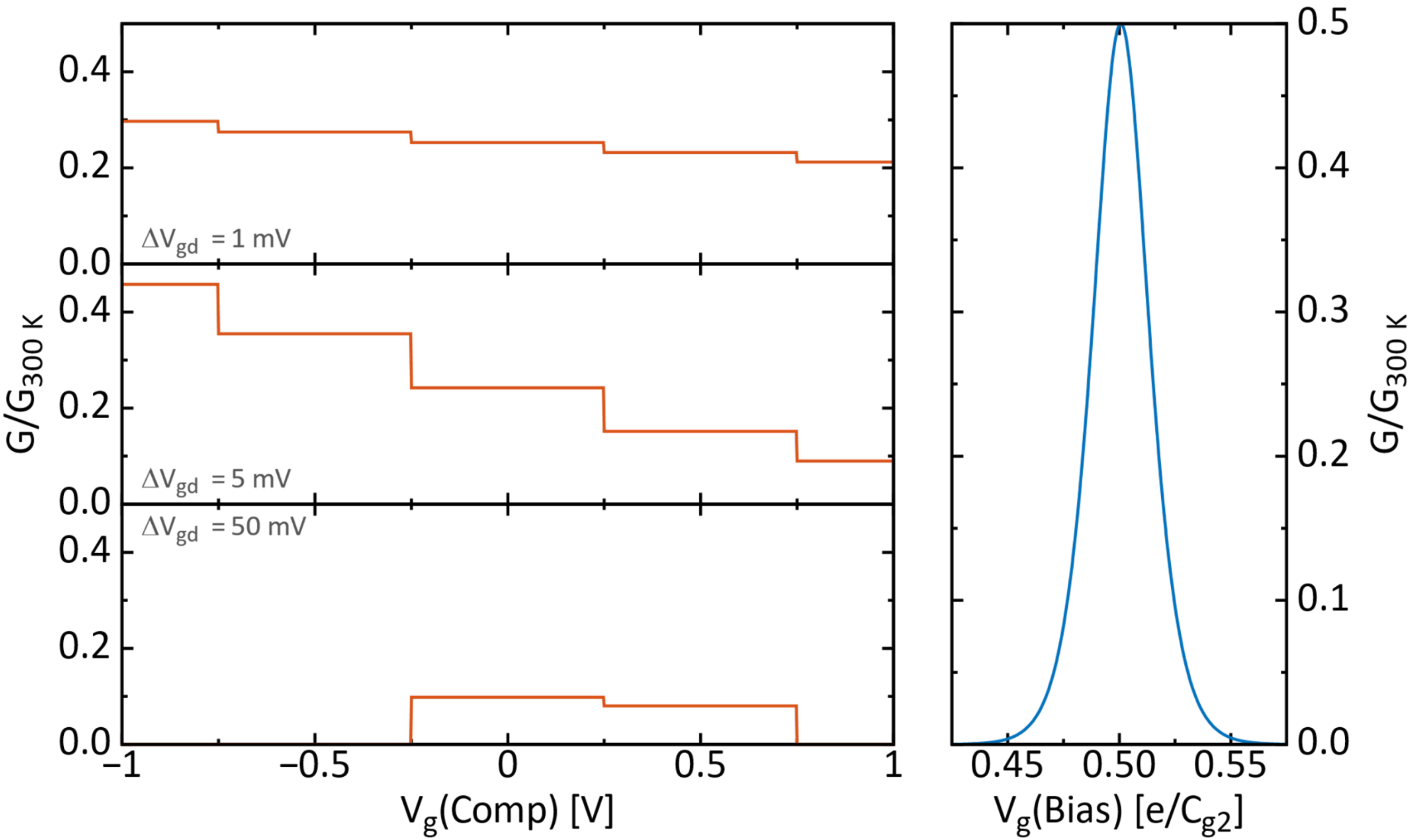
SET Charge Detector: 50 mV Signal



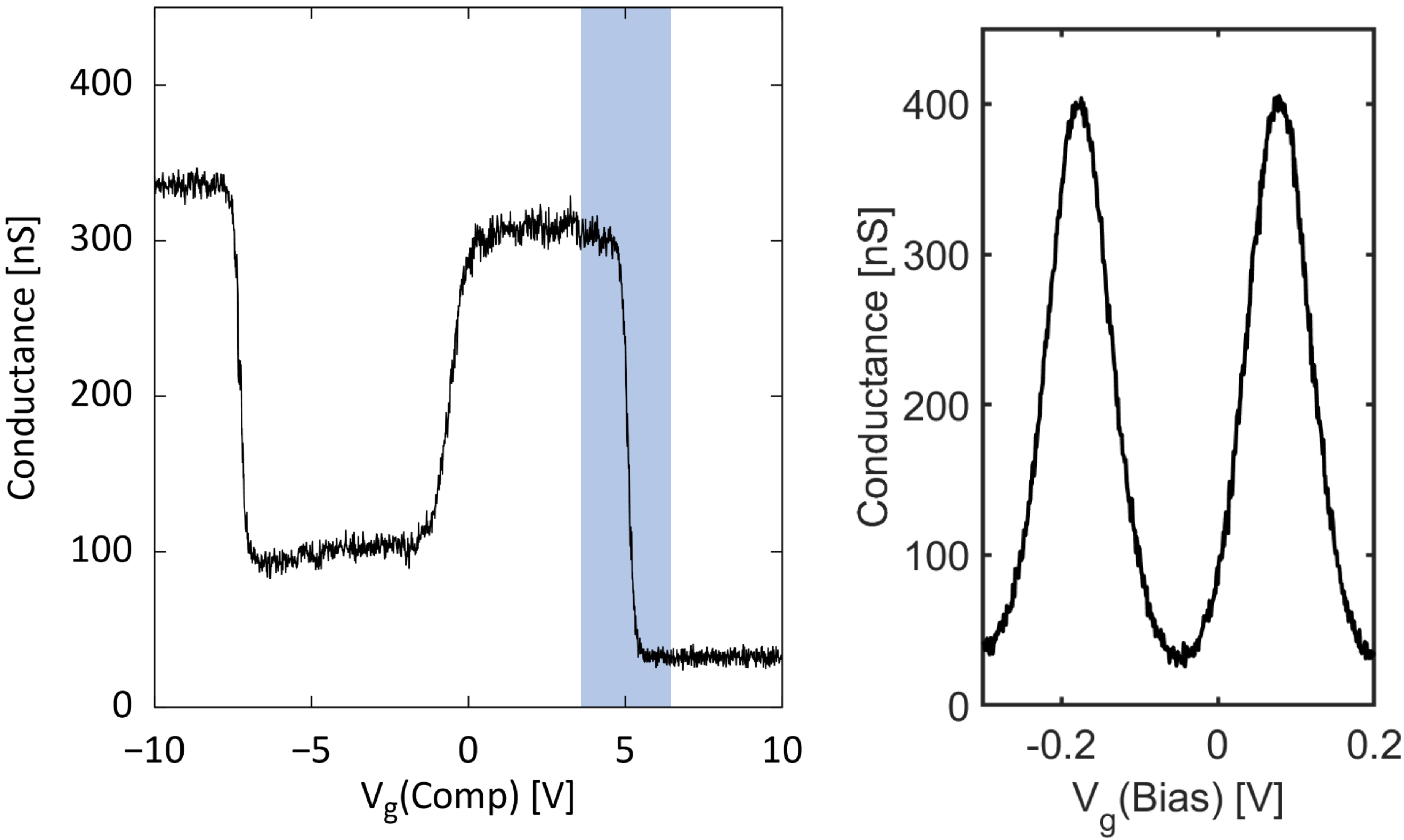
SET Charge Detector: 50 mV Signal



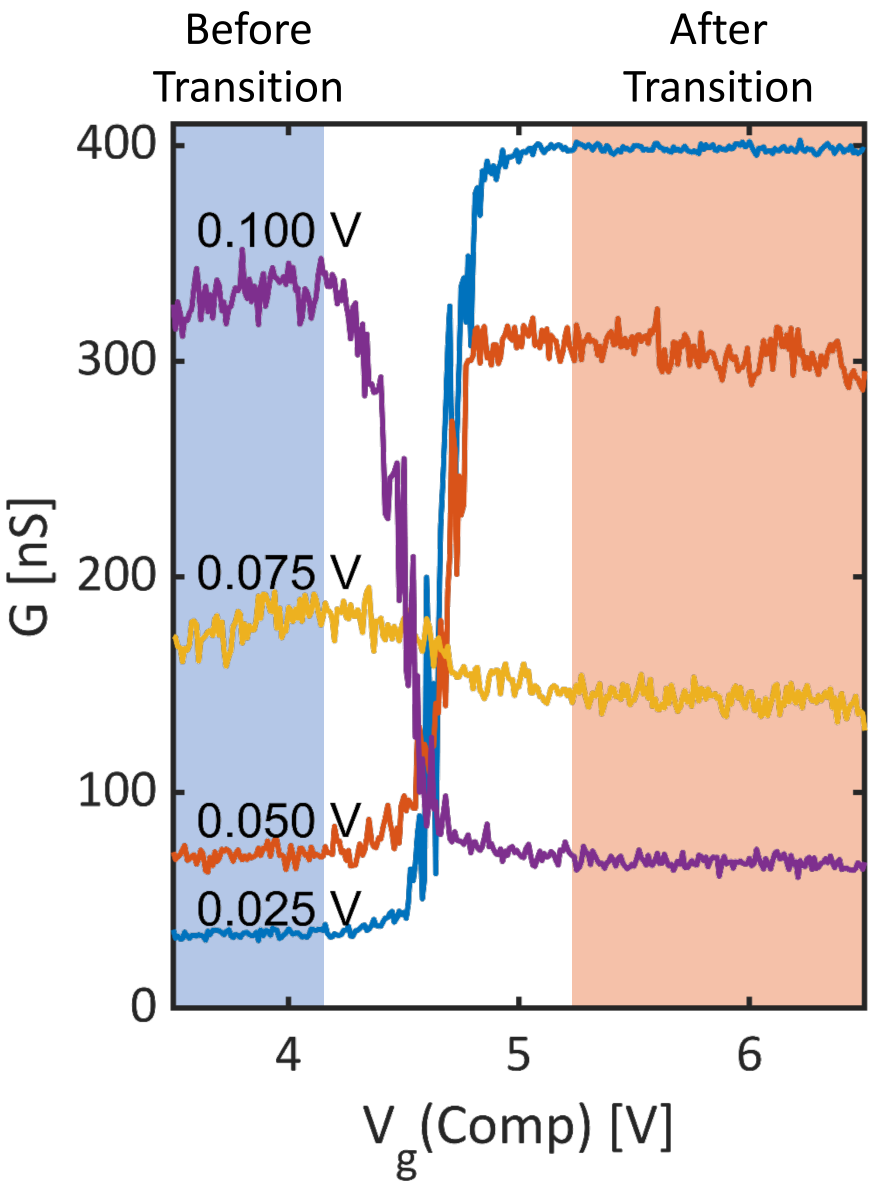
Compensated Measurement



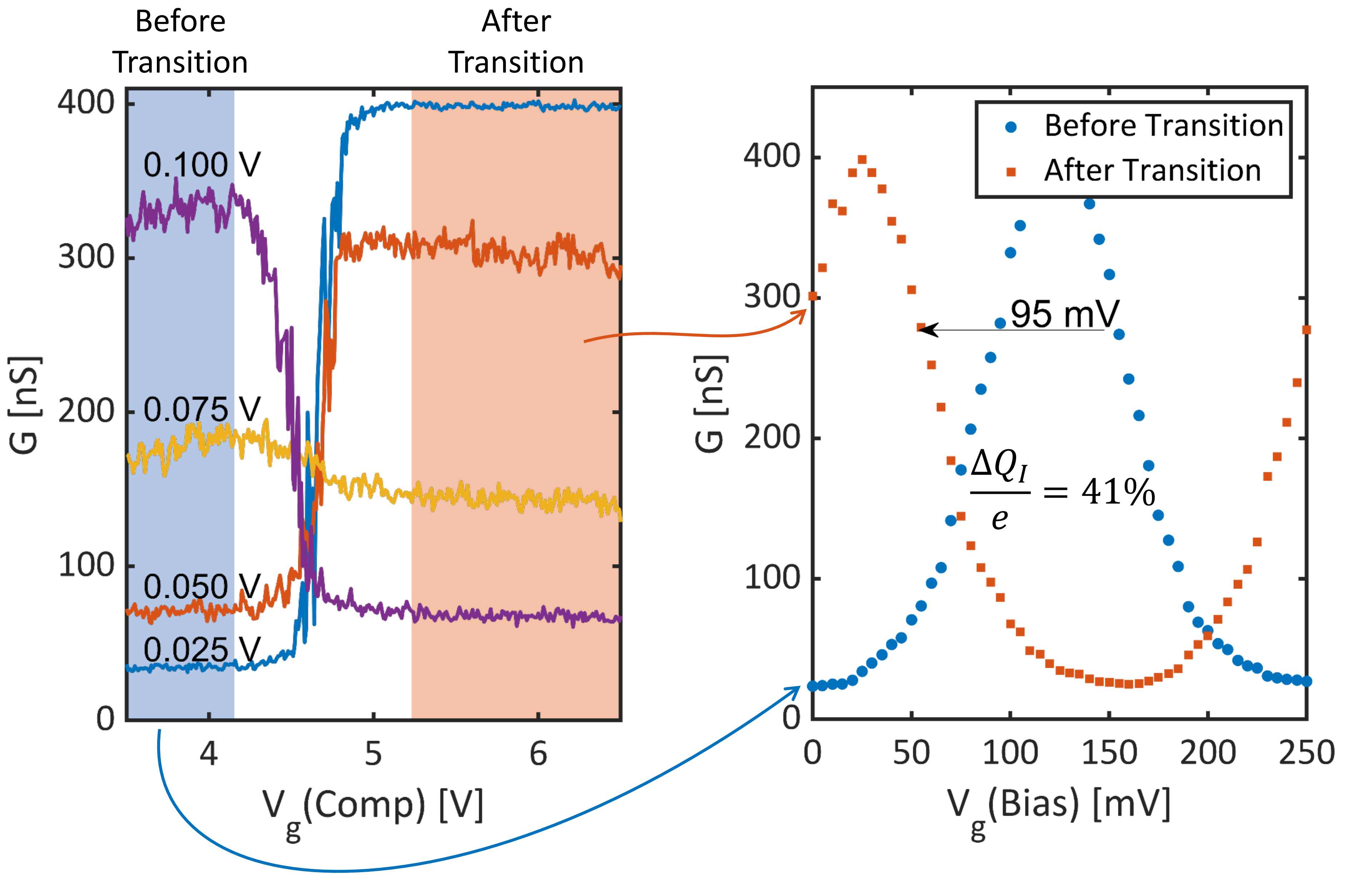
Measuring a Double Dot



Switching Analysis



Switching Analysis



References

[1] G. L. Snider, A. O. Orlov, I. Amlani, X. Zuo, G. H. Bernstein, C. S. Lent, J. L. Merz, and W. Porod, "Quantum-dot cellular automata: Review and recent experiments," Journal of Applied Physics, vol. 85, p. 4283, 1999.

[2] C. S. Lent, B. Isaksen, and M. Lieberman, "Molecular quantum-dot cellular automata," Journal of the American Chemical Society, vol. 125, pp. 1056-1063, JAN 29 2003.